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GROUP 4 POWER PLANT

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POWER PLANT — GENERAL

The power plant consists of two turbofan engines, one being mounted on each side of the rear fuselage. Each unit is mounted with a pod structure of fixed and removable hinged cowlings which give access to the engines. Stays are provided to support the hinged cowlings for maintenance purposes. Self-locking toggle hinges retain the cowlings closed.

Access panels in the cowlings facilitate routine servicing and maintenance checks. Slinging points permit the engines to be removed and installed with suitable lifting gear.

Each engine is mounted on two beams attached to fuselage frames, engine thrust being transmitted through a thrust strut extending rearward and inward from the engine front beam to the fuselage. Stub fillets enclose the engine beams between the engine pods and the fuselage. The stubs, through which system pipes, cables and control runs are routed, also accommodate auxiliary equipment, for which access panels are provided.

The exhaust system embodies a thrust reverser unit which deflects the thrust forward, above and below the pods to provide an efficient brake on landing.

Each nacelle embodies a fire detection system in Zone 1 and an overheat detection system in Zone 2. Both systems employ thermistor-type sensing elements routed round the inside of the cowlings. Two dual-head extinguisher bottles in the rear fuselage are connected to a spray pipe in Zone 1 of each nacelle, and the system permits a two-shot discharge to either engine in the event of fire.

The sensing elements in Zone 2 are connected to engine overheat warning lamps on the flight deck. All apertures through which systems enter the power plant are fireproofed.

A self-contained hot air system using air bleed from the H.P. compressor provides anti-icing for the power plant. In flight, ram-induced air ventilates the pods and stub fillets, maintaining the temperature at an acceptable level and preventing a vapour build-up, and at all times when the engine is running, the engine Zone 1 is cooled by a jet pump.

During ground running, the a.c. generator is cooled by an ejector system.

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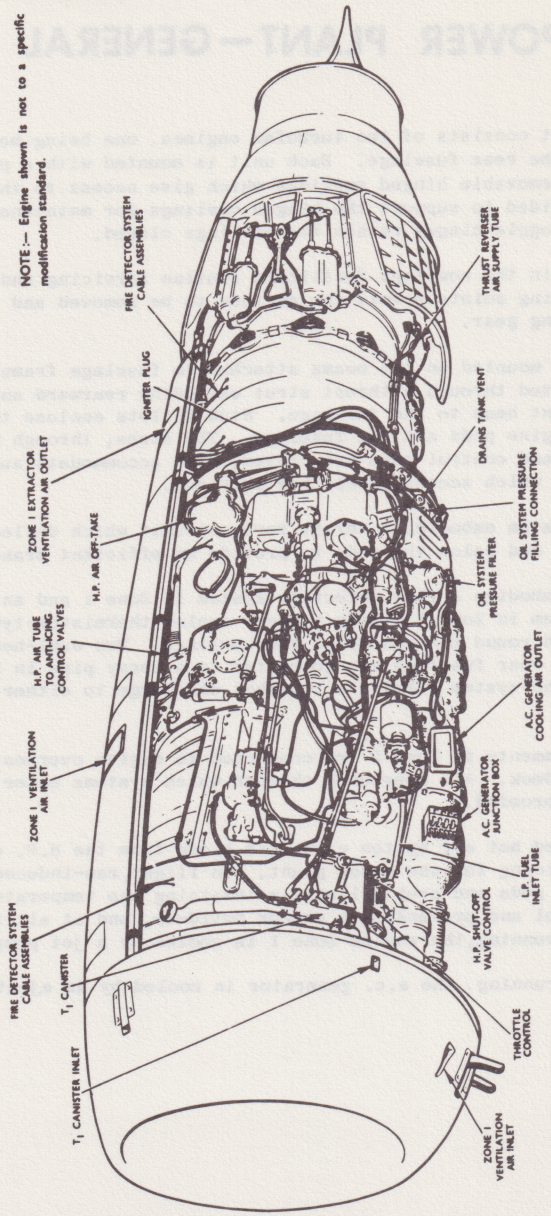

Power Plant - Left-hand
Figure 1

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NOTE: Engine shown is not to a specified modification standard.

Power Plant - Right-hand
Figure 2

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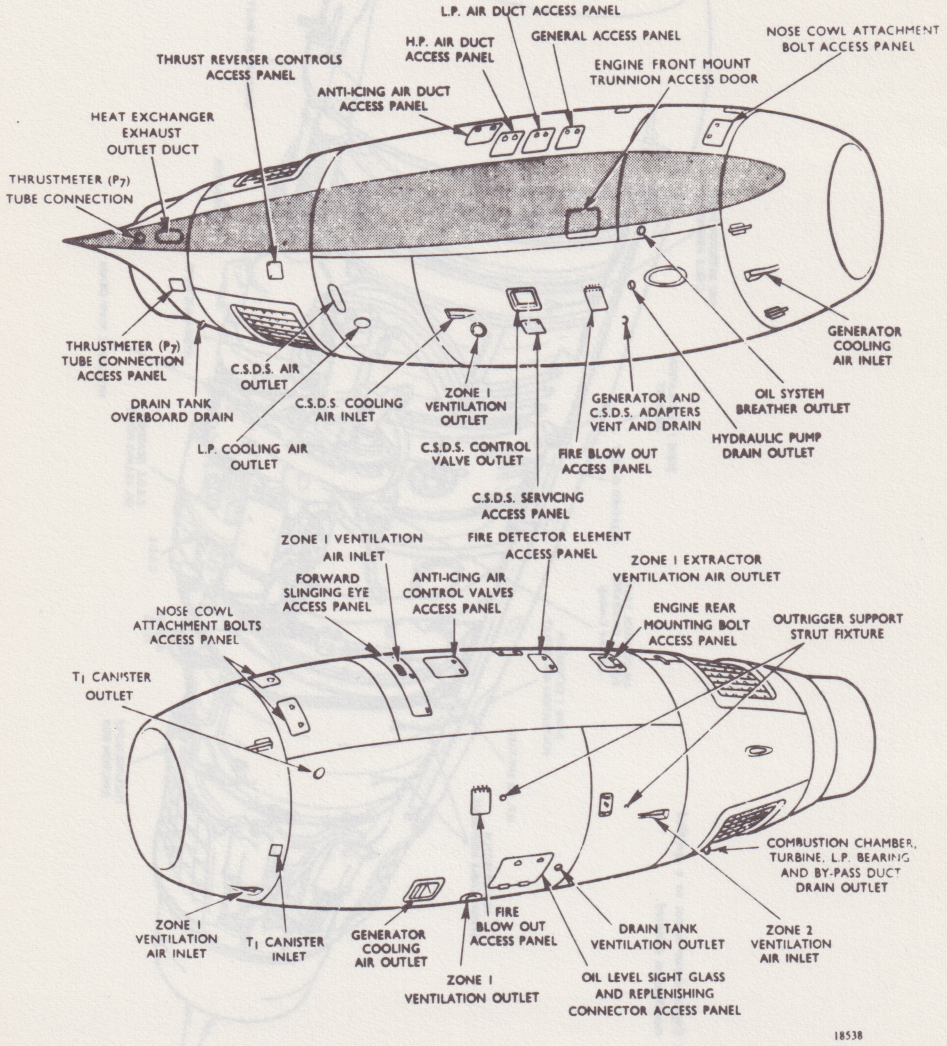

Access Panels and Apertures
Figure 3

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ENGINE

General

The Rolls Royce Spey Mk.512 14D (or Mk.512 14DW) engine is installed, the Mk.512 14DW being a 'wet' version, i.e., equipped to receive water injection. The engine is a turbofan with two axial flow compressors, each driven by its own turbine through coaxial shafts.

Air delivered by the first (low pressure) compressor is divided into two flows, one passing through a duct to by-pass the other flow which passes through the second (high pressure) compressor, combustion section and turbine, after which both flows mix in the exhaust mixer.

COMPRESSORS

The compressors consist of a five-stage LP compressor and a twelve-stage HP compressor. Helical splines couple each compressor shaft to its respective turbine shaft, the LP shaft rotating inside the HP shaft. The HP compressor is fitted with variable inlet guide vanes and a progressively-variable valve. Fitted to the outside of the diffuser case is the HP air manifold from which hot air is taken for anti-icing, fuel heating, CSDS supply, generator cooling, ejector pumps, thrust reverser operation, aircraft services and operation of the water injection system.

GEARBOXES - INTERNAL

The internal gearbox is fitted in the compressor intermediate case and provides two drives to external gearboxes. The main drive is from the HP shaft via bevel gears and a quill shaft to the right-hand gearbox. The other drive is from the LP shaft through bevel gears and a quill shaft to the left-hand gearbox.

RIGHT-HAND GEARBOX

This provides the driving gears and mounting faces for the following components:-

- HP r.p.m. indicator generator
- LP fuel pump
- Main oil pumps
- Fuel flow regulator
- Centrifugal breather
- Hydraulic pump
- AC generator
- Airflow control r.p.m. signal transmitter
- Constant speed drive and starter unit

LEFT-HAND GEARBOX

Provides the driving gears and mounting faces for:-

- LP r.p.m. indicator generator
- LP shaft governor

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AIR INLET CASE AND FRONT BEARING SUPPORT

1 Anti-icing air manifold
2 Anti-icing air tube
3 Air inlet nose fairing
4 L.P. inlet guide vanes

LOW PRESSURE COMPRESSOR

5 Stage one rotor blades
6 Stage one stator vanes
7 Interstage air seal
8 Rotor drum

COMPRESSOR INTERMEDIATE CASE

9 L.P. outlet guide vanes
10 L.P. compressor rear bearing
11 Left-hand gearbox driving gear
12 Right-hand gearbox driving gear
13 H.P. compressor front bearing
14 H.P. compressor variable inlet guide vanes

HIGH PRESSURE COMPRESSOR

15 Stage one rotor blades
16 Stage one stator vanes
17 Seventh stage air bleed valve
18 L.P. compressor intermediate shaft
19 Rotor drum

DIFFUSER CASE

20 H.P. compressor outlet guide vanes
21 Primary air scoops
22 H.P. shafts thrust bearing
23 L.P. shafts thrust bearing

COMBUSTION CASE

24 Fuel spray nozzle
25 Interconnector
26 Liner

TURBINES

27 H.P. turbine shaft
28 H.P. turbine bearing
29 L.P. cooling air manifold
30 H.P.1 nozzle guide vanes
31 H.P.1 turbine blades
32 H.P.2 nozzle guide vanes
33 H.P.2 turbine blades
34 L.P.1 nozzle guide vanes
35 L.P.1 turbine blades
36 L.P.2 nozzle guide vanes
37 L.P.2 turbine blades
38 L.P. turbine shaft
39 L.P. turbine bearing

EXHAUST MIXER

40 L.P. turbine bearing housing spokes
41 Exhaust cone
42 T_6 thermocouples
43 Mixer flare

Key to Figure 1

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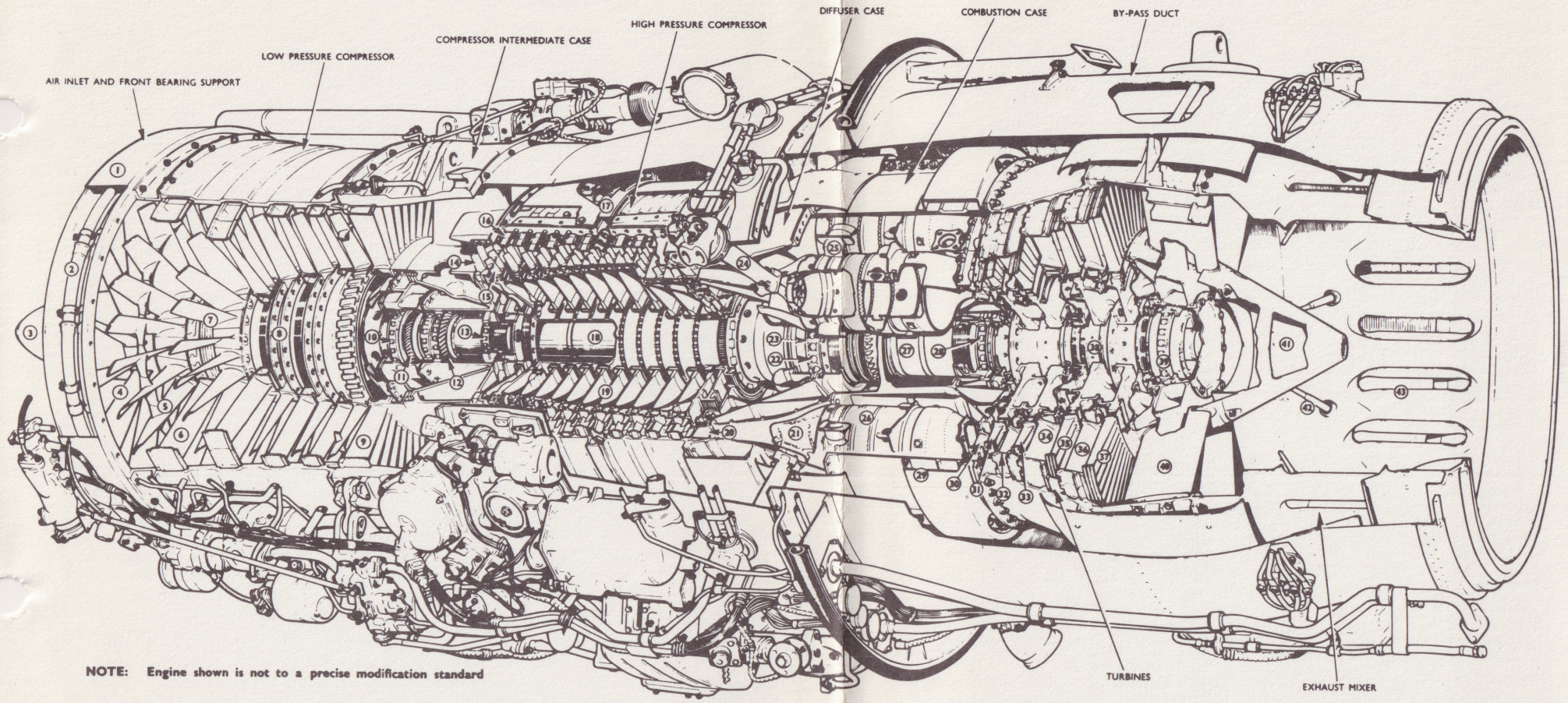

NOTE: **Engine shown is not to a precise modification standard**

Typical Engine - Internal
Figure 1

COMBUSTION SECTION

Consists of the ten interconnected liners fitted inside the combustion chamber case. Each liner is fitted with a nozzle which directs a fine spray into the liner, where it mixes with air and the mixture is burnt. Igniter plugs in Nos. 4 and 8 liners provide the initial combustion of the mixture when starting the flame spreading to the other liners through the interconnectors.

TURBINE SECTION

The turbine section consists of:-
Nozzle case and guide vanes
HP turbine bearing support
HP turbine
LP turbine bearing support
LP turbine
Exhaust mixer
The nozzle guide vanes accelerate the gas from the combustion section and direct the stream on to the turbine blades, the turbines accelerate to high speed under the force and provide the motive power for driving the compressors and accessories.

The exhaust mixer ducts the by-pass air down into the gas flow to ensure efficient mixing of the two streams in the exhaust unit.

BY-PASS DUCT

The duct is a titaniun casing that forms an annulus around the rear half of the engine, where it extends from the compressor intermediate case to the exhaust mixer.

Air from the LP compressor is divided into two streams; one passes through the by-pass annulus, the other through the HP compressor, thence to the combustion and turbine sections. The two streams join in the exhaust unit and are then discharged to atmosphere through the propelling nozzle. The airflow through the by-pass duct is in the ratio of 0.7 to 1 to the flow through the HP compressor.

FUEL SYSTEM

Fuel flow, for starting and stopping, is controlled by a HP fuel S.O.V. lever. Should the LP shaft fail, the shaft failure system responds to close the S.O.V.

When the throttles are set to give a selected r.p.m., fuel flow is automatically controlled by the fuel flow regulator which is sensitive to fuel flow, engine speed and HP compressor airflow.

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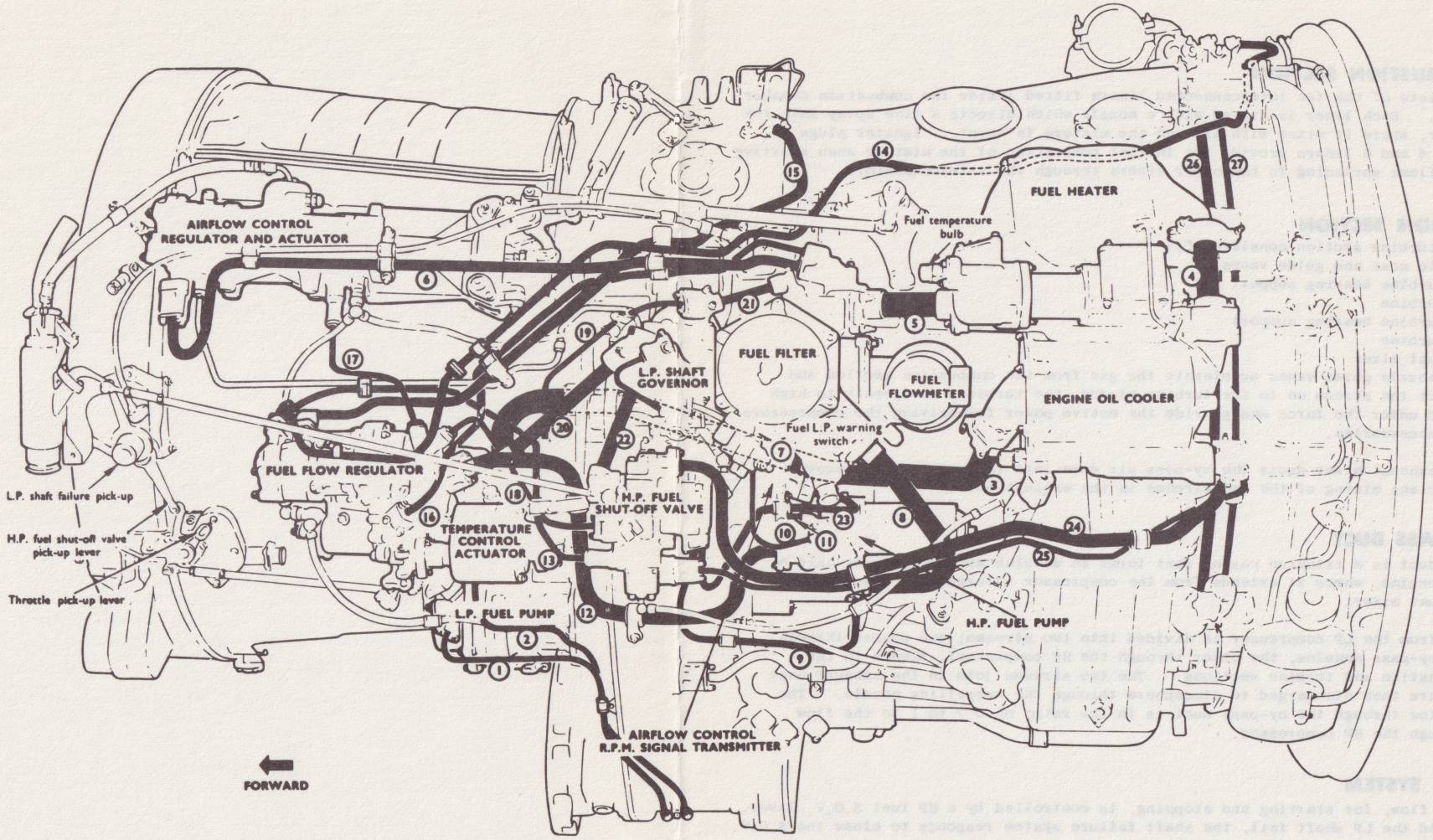

Fuel System Arrangement (See also Fig.3)
Figure 2

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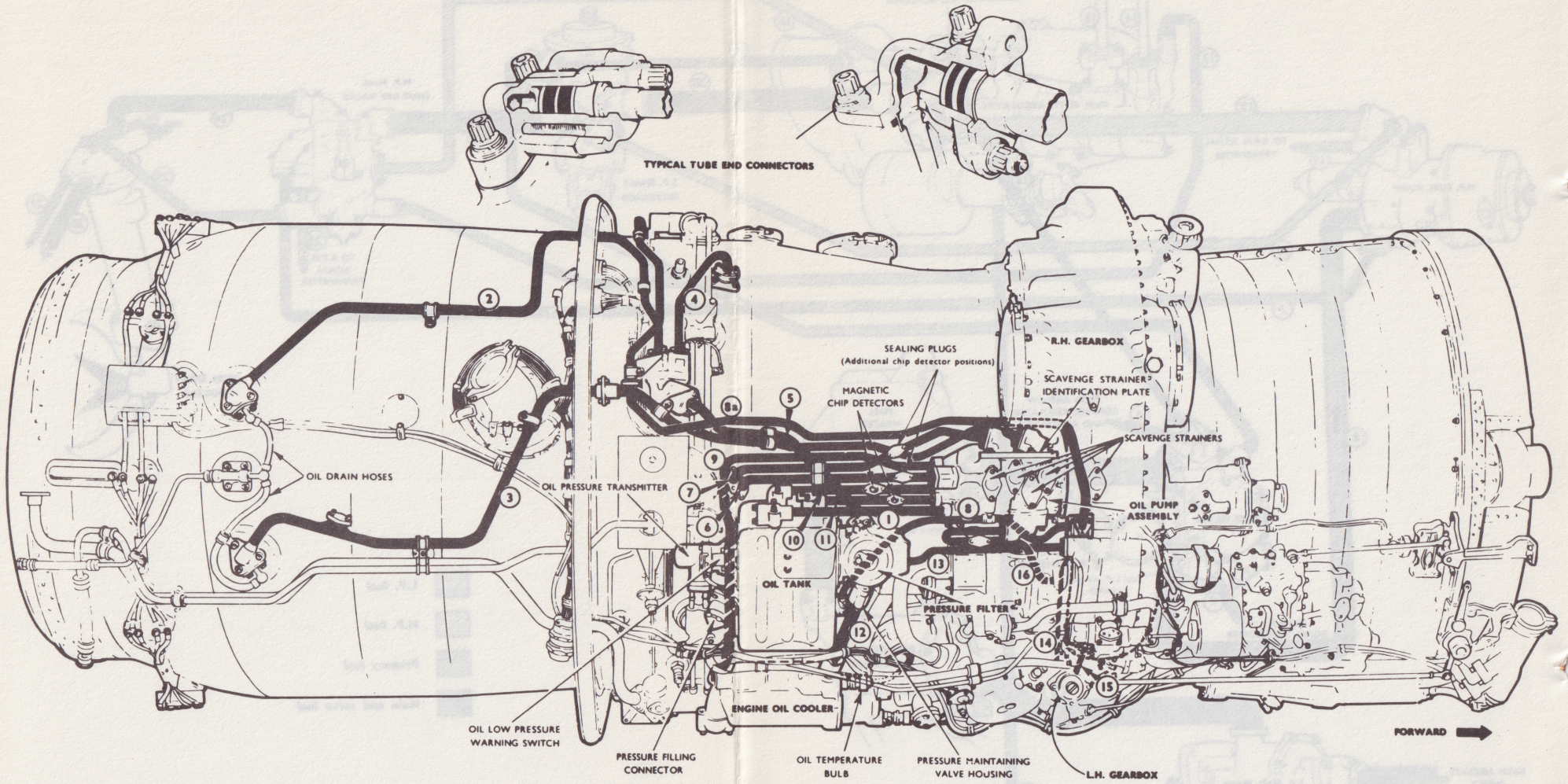
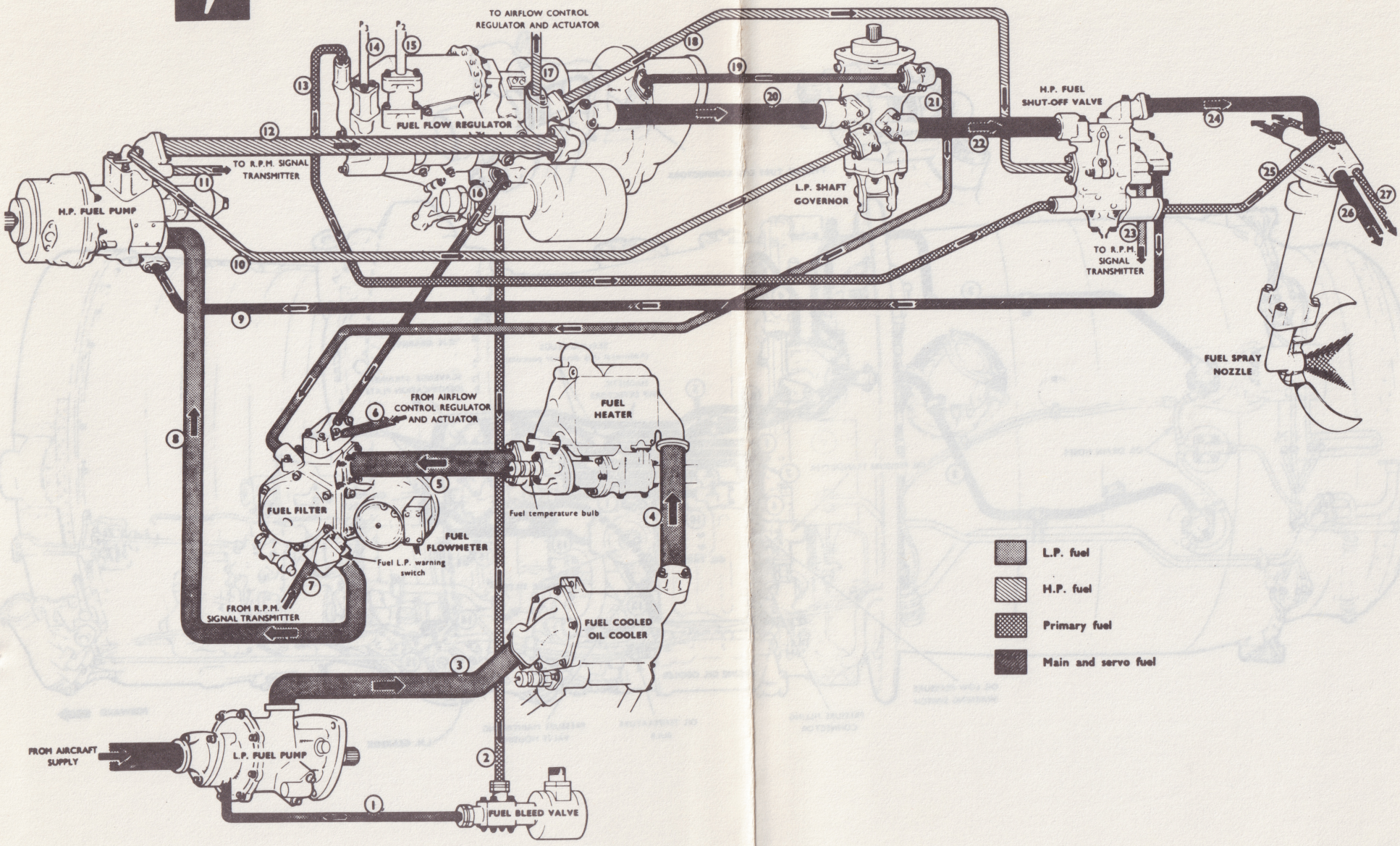


Oil System Arrangement (See also Figure 5)
Figure 4



Fuel Flow Diagram (See also Figure 2)
Figure 3

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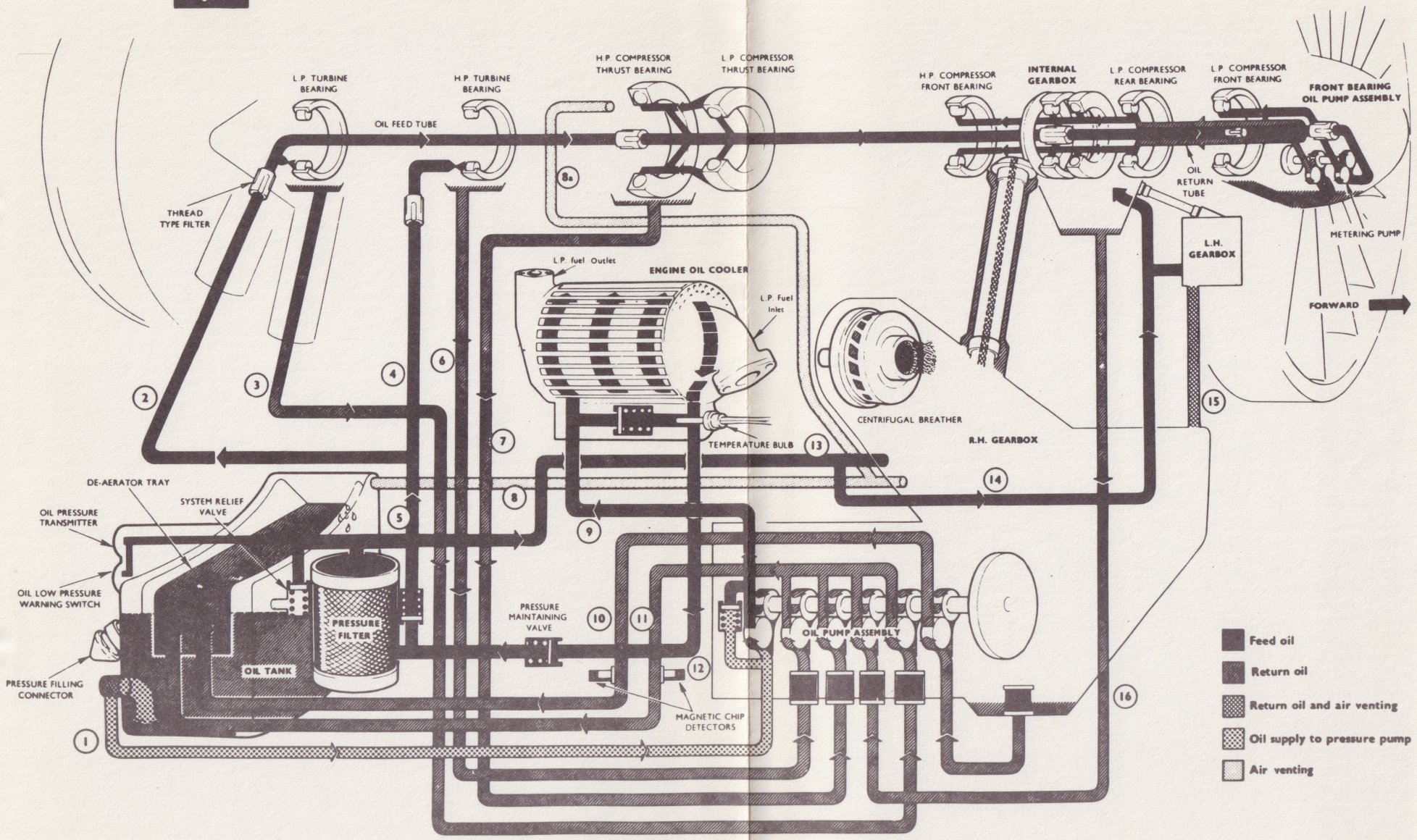

Oil Flow Diagram (See also Figure 4)
Figure 5

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FUEL SYSTEM (Concluded)

In the event of excessive LP compressor shaft speed, HP compressor delivery pressure or thrust, or turbine gas temperature; a LP shaft governor, P3 limiter, turbine temperature control actuator and over-temperature control solenoid respond to override the throttle setting.

Distribution commences from a LP pump delivering from the aircraft supply to the oil cooler and then to a thermostatically-controlled, HP compressor-heated fuel heater. During starting and exceptionally cold running, the fuel heater operates to give a minimum outlet temperature of 5 deg.C (41 deg F) but during normal running sufficient heat is exchanged in the oil cooler to prevent ice formation in the fuel.

From the heater, fuel flows through the filter, flowmeter transmitter to the HP fuel pump, thence to the regulator where it divides into two flows at different pressures; the spray nozzle primary and main flow.

Manifold tubes deliver both flows to the spray nozzles.

WATER INJECTION

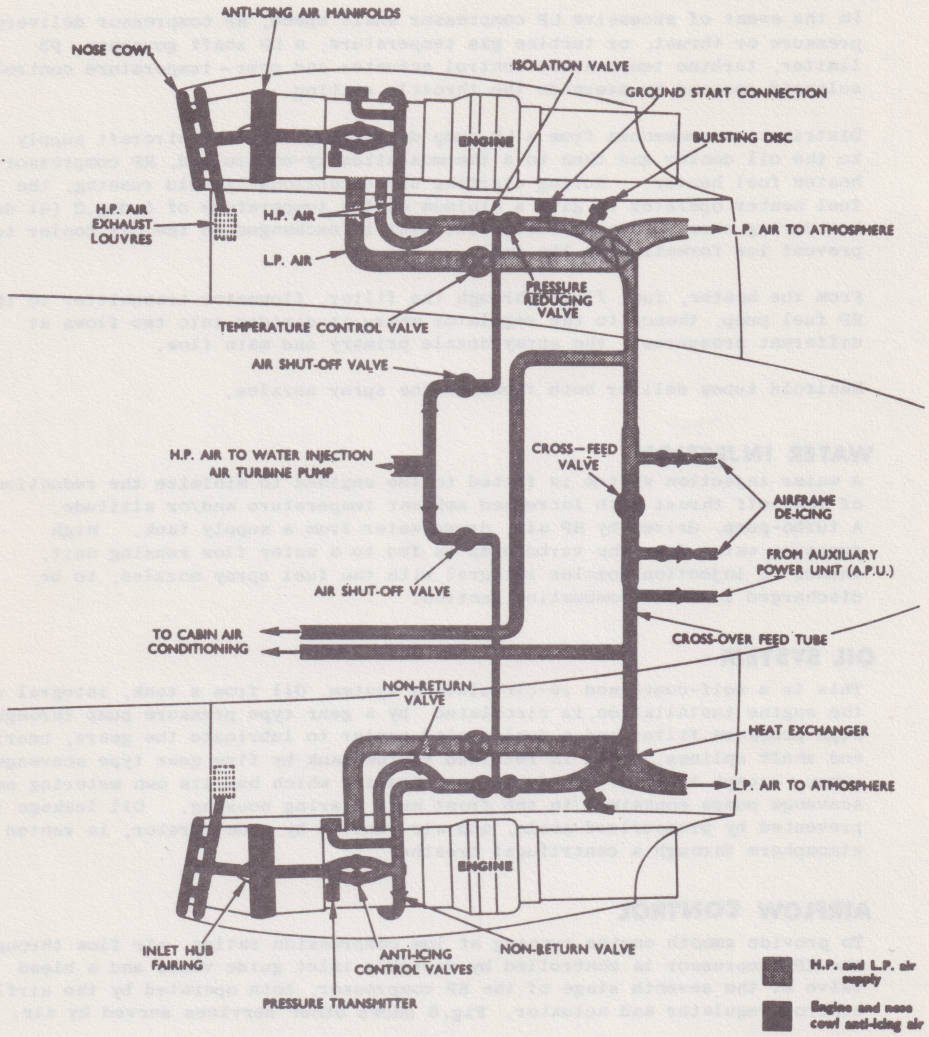
A water injection system is fitted to the engines to minimize the reduction of take-off thrust with increased ambient temperature and/or altitude. A turbo-pump, driven by HP air, draws water from a supply tank. High pressure water from the turbo-pump is fed to a water flow sensing unit, thence to injection nozzles integral with the fuel spray nozzles, to be discharged into the combustion section.

OIL SYSTEM

This is a self-contained re-circulating system. Oil from a tank, integral with the engine installation, is circulated by a gear type pressure pump through a high pressure filter and a fuel-cooled cooler to lubricate the gears, bearings and shaft splines. Oil is returned to the tank by five gear type scavenge pumps, except that for the front main bearing which has its own metering and scavenge pumps contained in the front main bearing housing. Oil leakage is prevented by pressurized seals, and air removed by a de-aerator, is vented to atmosphere through a centrifugal breather.

AIRFLOW CONTROL

To provide smooth engine running at low compression ratios air flow through the HP compressor is controlled by variable inlet guide vanes and a bleed valve at the seventh stage of the HP compressor, both operated by the airflow control regulator and actuator. Fig.6 shows other services served by air.



Air Off-takes - Diagrammatic
Figure 6

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COOLING AND SEALING

Air tapped from both compressors is used to cool the engine and pressurize the seals to prevent oil and gas leakage. Air from the HP compressor is also used to cool the first stage of HP turbine blades and both stages of the HP nozzle guide vanes.

ANTI-ICING

Formation of ice on the engine air inlet is prevented by hot air ducted from the HP air manifold, through two anti-icing control valves to the air inlet anti-icing manifold. Hot air from this source de-ices the inlet guide vanes, the air inlet hub fairing and the nose cowl.

STARTING

An air driven constant speed drive and starter (CSDS) is used to rotate the engine. Combustion is initiated by igniter plugs in two of the liners, high-energy being supplied from igniter units. Starter air is supplied from either the APU, a ground supply, or from the other engine.

FIRE SEAL

A rectangular frame and a flexible seal is secured to a flange on the by-pass duct, separating the cooler front zone of the engine from the hotter rear zone.

FUEL LEAKAGE

Any leakage past the seals of fuel-operated units, and any unburnt fuel in the engine due to a false start or failure to start is either drained overboard, or routed to a collector tank on the underside of the engine. A suction pipe runs aft from the tank to terminate at an outlet which protrudes through the nacelle rear fairing where, in flight, fuel is withdrawn from the collector tank by a depression induced by the airstream.

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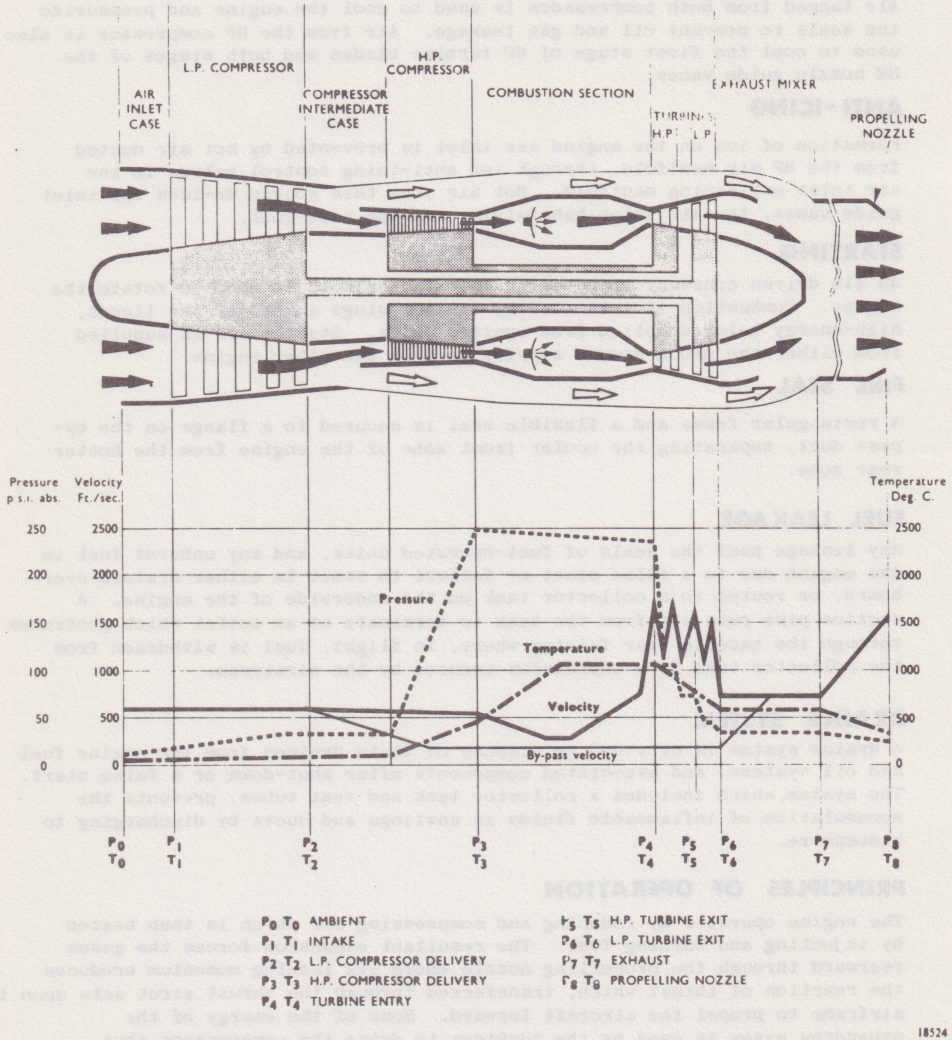
DRAINS SYSTEM

A drains system is provided to dispose of fluid drained from the engine fuel and oil systems, and associated components after shut-down or a false start. The system, which includes a collector tank and vent tubes, prevents the accumulation of inflammable fluids in cowlings and ducts by discharging to atmosphere.

PRINCIPLES OF OPERATION

The engine operates by inducing and compressing air which is then heated by injecting and burning fuel. The resultant expansion forces the gases rearward through the propelling nozzle where its issuing momentum produces the reaction of thrust which, transferred through the thrust strut acts upon the airframe to propel the aircraft forward. Some of the energy of the expanding gases is used by the turbines to drive the compressors thus producing a continuous cycle.



Gas Flow Diagram
Figure 7

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As the thrust developed by the engine is mainly a function of the mass of air flowing through it and the temperature of the gases at the turbine inlets, the power output can be controlled by regulating the amount of fuel injected into the combustion section. The amount of fuel required for normal operation is a function of HP compressor shaft speed. Therefore, a change in the HP compressor shaft speed requires a change in the fuel flow to produce a change in thrust and LP compressor shaft speed.

The trend of the pressure, temperature, and velocity changes of the gas flow through the engine at take-off condition is shown in Fig.7.

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ENGINES - SERVICING

General

The complete oil system is housed within the engine structure, the supply tank being located on the lower left-hand side of the engine, where it is mounted on the by-pass duct.

The tank is replenished through a pressure connector mounted on the aft face of the tank, and a suitably graduated sight glass gives visual indication of the oil level. Provision is also made for gravity filling, to be used only in emergencies.

Oil is normally drained from the tank through the tank drain valve and the pressure filter drain valve, which are located on the front and rear faces of the oil tank respectively. A drain plug is fitted in the base of the tank for complete draining when required.

The oil system includes filters, scavenge strainers and easily-removable magnetic chip detectors.

The fuel system includes a low pressure filter.

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APPROVED OILS

3 CENTISTOKE		5 CENTISTOKE (TYPE 11)			
Castrol	Aeroshell	Esso	Mobil	Chevron	Caltex
3C and 325	Turbo 390	Turbo 2380	Jet 11	Jet 5	RPM Jet 5

Re-use of an approved oil is permitted only when such oil has been reclaimed to the standards of Rolls-Royce Spec. W.P.S.293 for 3 centistoke (British) or 15 centistoke (American) oils.

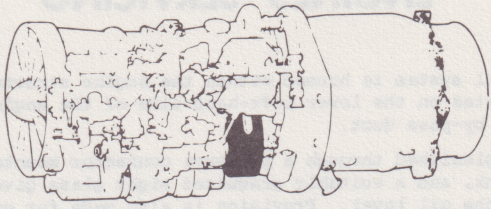
CAPACITIES	Imp. Pints	U.S. Pints	Litres
Complete system	24.0	28.8	13.6
Tank only	12.0	14.4	6.8
Usable oil	9.0	10.8	5.1
Consumption Max. Permissible/hour	0.75	0.90	3.8

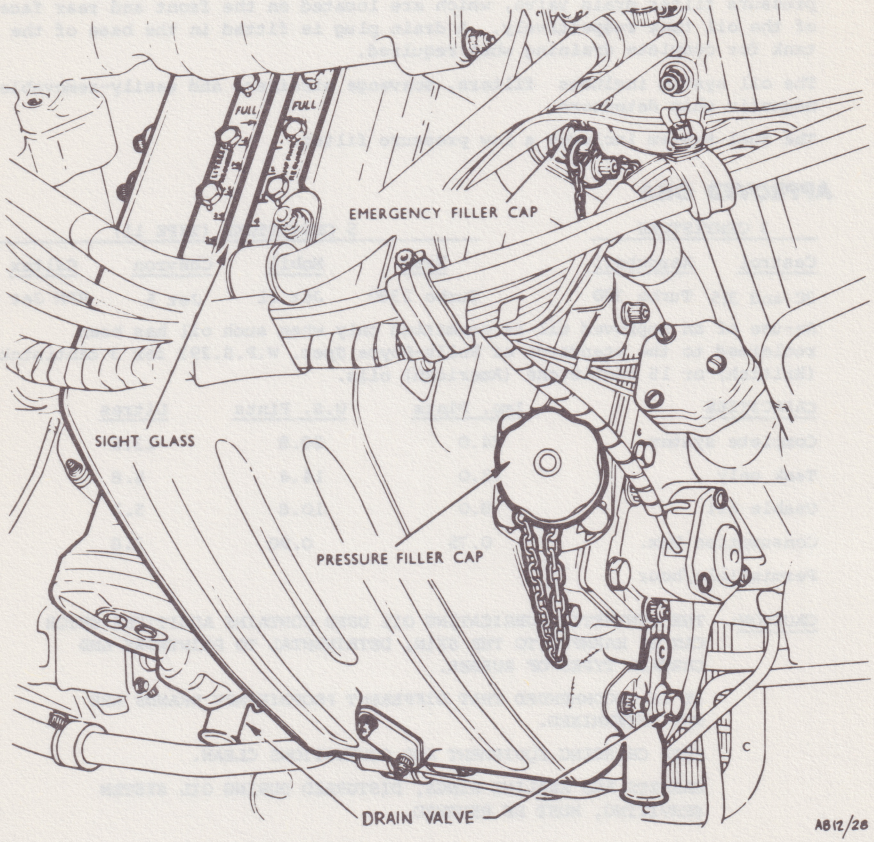
CAUTION: THE SYNTHETIC LUBRICATING OIL USED CONTAINS ADDITIVES WHICH CAN BE HARMFUL TO THE SKIN, DETRIMENTAL TO PAINTWORK AND CERTAIN TYPES OF RUBBER.

IT IS RECOMMENDED THAT DIFFERENT PROPRIETARY BRANDS ARE NOT INTERMIXED.

KEEP CHARGING EQUIPMENT AND CONNECTIONS CLEAN.

GASKETS AND SEALING RINGS, DISTURBED DURING OIL SYSTEM SERVICING, MUST BE RENEWED.





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Oil Filling and Drain Points
Figure 101

CHECKING OIL LEVEL

IMPORTANT: Allow at least 5 minutes to elapse after engine shutdown before checking oil level.

1. With the aid of an approved flame-proof torch, observe the tank sight glass and record the amount of oil required to fill the system.

   NOTE: If the oil level is not registering, record this fact.

2. If necessary replenish with oil, using one of the two methods described below.

REPLENISHING - WITH PRESSURE CHARGING RIG

1. Check the oil level as described above.
2. Couple the rig to the tank connection, and pump in the quantity of oil recorded during the oil level check, taking care not to overfill the tank; record the total amount added.
3. Disconnect the rig from the tank connection, secure the cap and the access panel.

REPLENISHING - WITH SYRINGE (EMERGENCY) (Fig. 101)

1. Open the access panel and check the oil level as previously described.
2. Remove the emergency filler cap and discard the sealing gasket.
3. Using a clean syringe, inject through the emergency filler the quantity of oil recorded in the oil level check, taking care not to overfill the tank; record the total amount added.
4. Fit a new sealing gasket to the emergency filler cap, fit and secure the cap, and secure the access panel.

DRAINING OIL SYSTEM (Fig. 101)

The oil tank and the pressure filter can each be drained independently. To facilitate draining, both drain valves may be open at the same time.

Before draining, clean the exterior of the drain valves and, provide a clean receptacle with a capacity of 3 Imp.galls. (3.6 U.S.galls. 13.6 litres) beneath the engine.

After draining, examine the drained oil for evidence of contamination; refill the system as soon as possible with the approved type of oil. During servicing renew all seals and gaskets. Check for absence of leaks at the next engine run.

PRESSURE FILTER (Fig. 102)

The filter element should be removed during periodic checks, or when the condition of the engine is suspect and examined for deposit of metal particles.

Wash the element and cover in kerosine, and strain the residue through a filter paper. Thoroughly dry the element with clean, compressed air and immerse in clean engine oil before refitting; torque-tighten the end cover capnut to 100 lb.in., and fit the lockplate.

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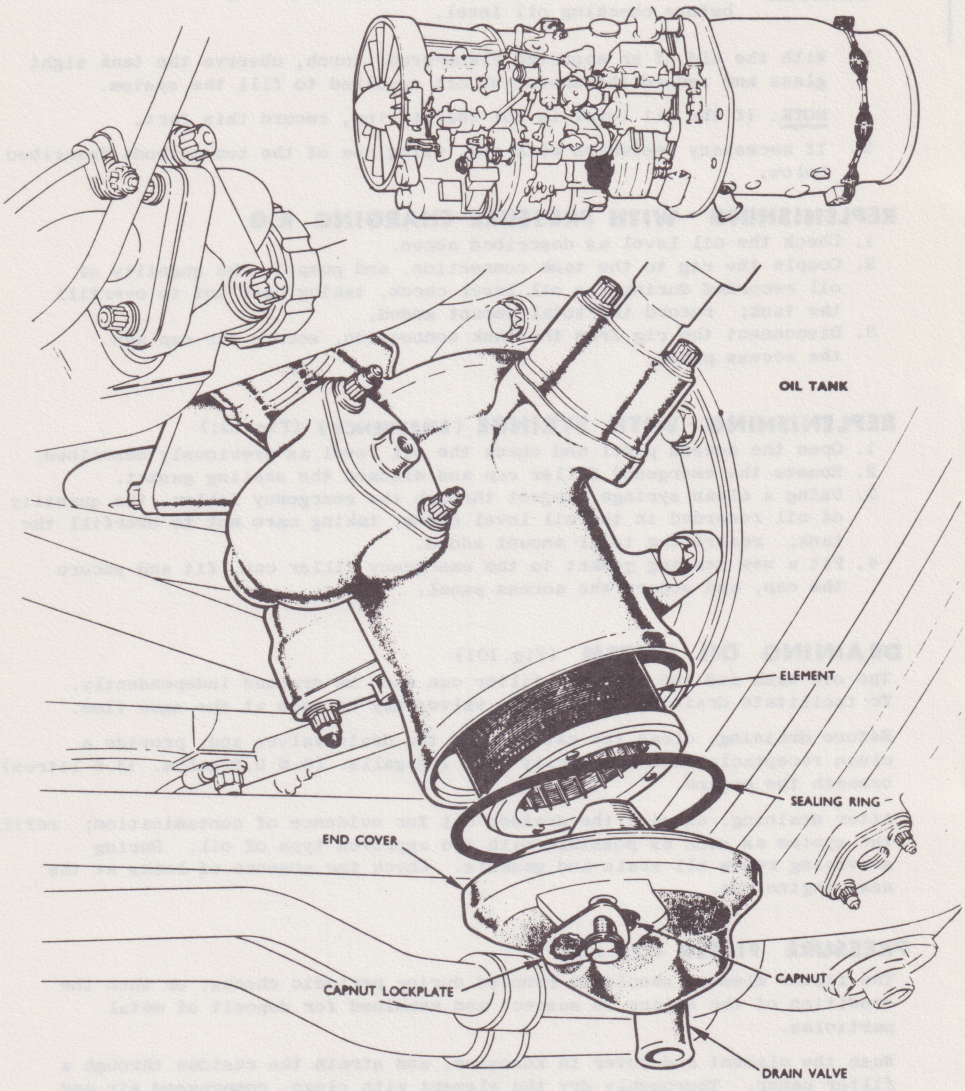

Pressure Filter
Figure 102

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If metal deposits were found in the filter, they must be submitted for analysis.

Isolated particles of aluminium, magnesium and small shreds of rubber or fluff are acceptable. Metal fragments or pieces of rubber that can be identified as part of a rubber sealing ring, necessitates the rejection of the engine. The removal and examination of the chip detectors may provide additional evidence for suspected internal failure.

Where fine bronze or steel particles are present, clean and replace the filter, replenish the oil system and make a further check after a 10 minute engine run through the whole-speed range, including one minute at take-off r.p.m.

If further metal particles, which indicate a suspected internal failure are found, following the engine run, the particles must be wrapped, labelled and returned with the engine for further investigation.

SCAVENGE STRAINERS (Fig.103)

The scavenge strainers provide a means of individually checking the engine bearings in the event of suspected deterioration. They should be examined for metal deposits when necessary.

To remove strainers, use special tools Part Nos.UT.360 and HU2648. Identify each strainer for reference purposes.

Wash, dry and immerse in clean engine oil before refitting.

MAGNETIC CHIP DETECTORS (Fig.104)

The magnetic influence of the detectors attract and retain small particles of steel released into the system and thus provide, during periodic inspections, an early warning of possible engine failure.

There are normally two detectors fitted but two additional may be installed, in the oil return lines upstream of the scavenge pumps.

The 'bayonet' sockets are self-sealing to prevent loss of oil when the detectors are withdrawn for inspection.

Remove and carefully immerse in white spirit before examination.

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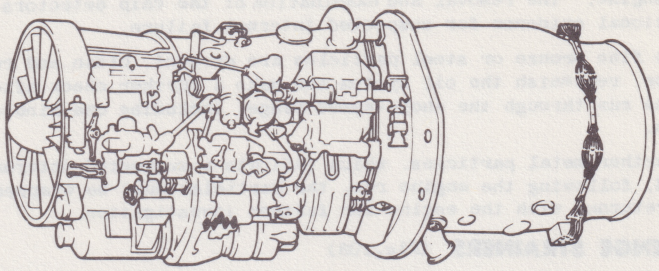

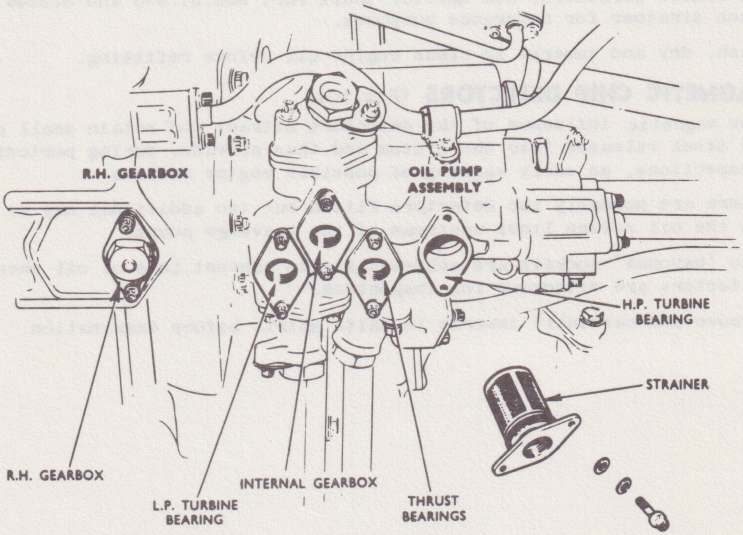

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Scavenge Strainers
Figure 103

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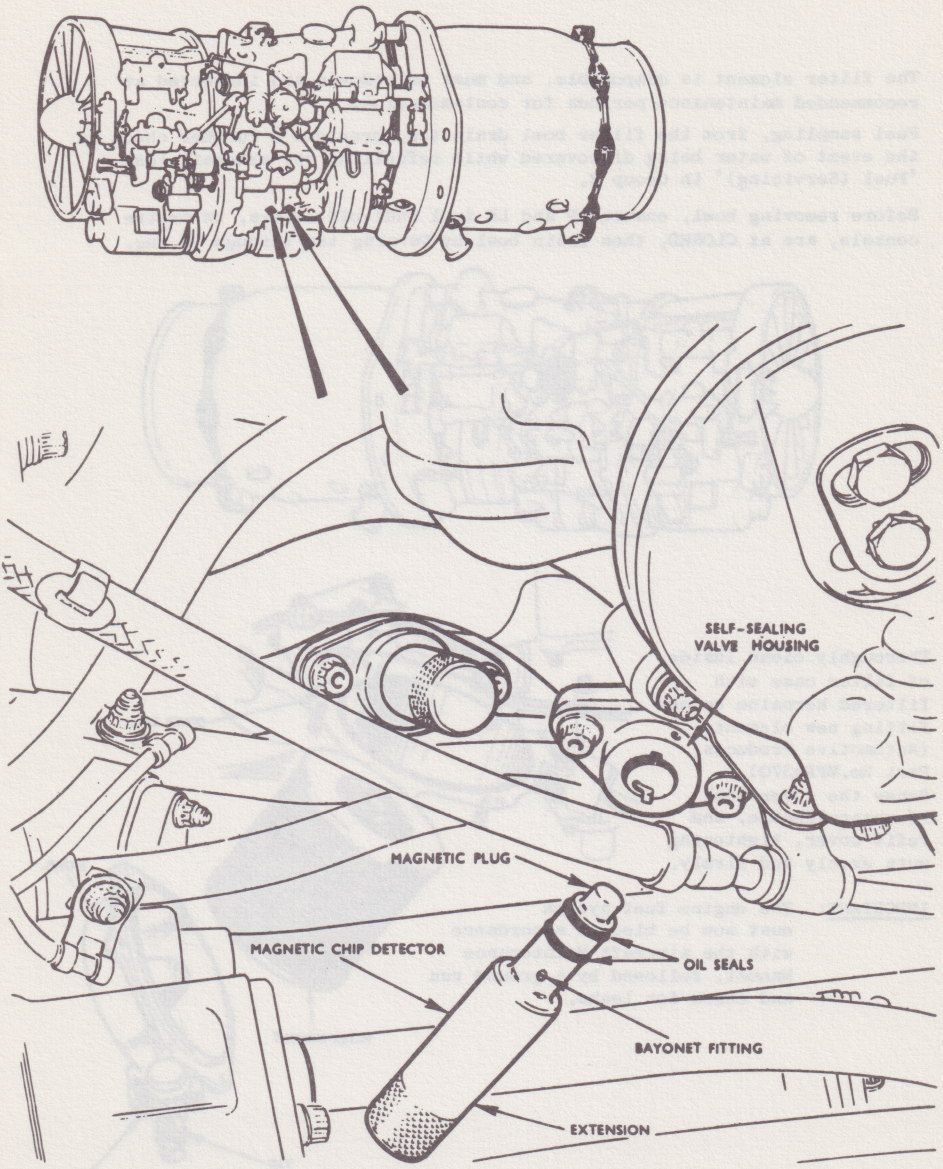
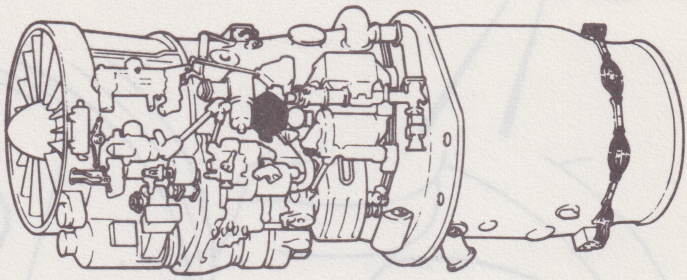


Magnetic Chip Detectors
Figure 104

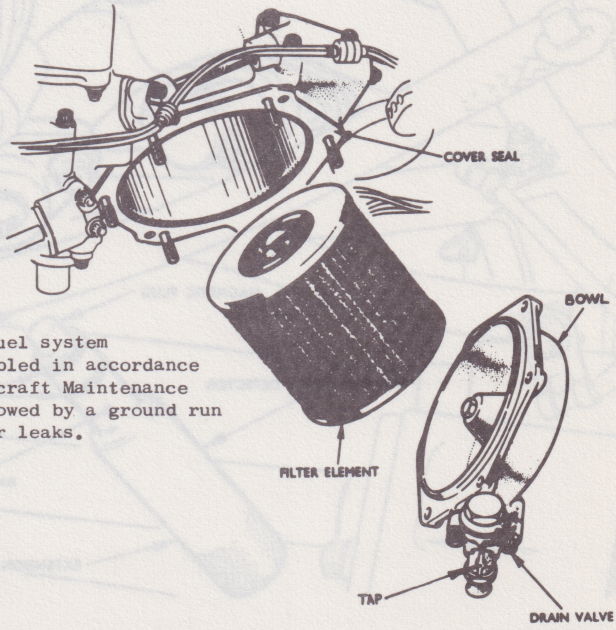
The filter element is disposable, and must be removed and inspected at recommended maintenance periods for contamination.

Fuel sampling, from the filter bowl drain tap, provides a further check in the event of water being discovered while refuelling the aircraft (see 'Fuel (Servicing)' in Group 2.

Before removing bowl, ensure HP and LP fuel shut-off levers, on centre console, are at CLOSED, then drain bowl by turning tap through 90 deg.



Thoroughly clean inside of filter case with filtered kerosine before fitting new element (Automotive Products Part No.MFFA370). Renew the cover seal if unserviceable, and refit cover, tightening nuts evenly and firmly.



IMPORTANT: The engine fuel system must now be bled in accordance with the aircraft Maintenance Manual, followed by a ground run and check for leaks.

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Fuel LP Filter
Figure 105

CONTROL

General

The engines are controlled, by manually-operated throttle and high pressure shut-off valve (HP S.O.V.) levers on the centre console.

A lever, pivot-mounted at the top of the throttle lever, provides selection and control of reverse thrust.

The throttle and HP S.O.V. control linkages in the console are interconnected by micro-switches to electrically controlled engine services and aircraft warning circuits.

An LP shaft failure system on each engine is connected to the HP S.O.V. control linkage to provide an emergency shut-down in the event of shaft failure between the LP compressor and the LP turbine.

For starting, and with engines operating, the HP S.O.V. control levers are fully open, and fuel flow to the engines is controlled by the throttles.

FORWARD THRUST

The throttle levers control the speed control governors on each engine fuel flow regulator, thereby controlling engine power during forward thrust.

REVERSE THRUST

To select reverse thrust, the throttle levers are first moved to the idle position and the reverse thrust lever lifted. This controls selector/sequence valves which open to admit P3 air to the thrust reverser door actuating jacks.

A baulk in the control system restricts movement of throttle levers from reverse idle r.p.m. to approximately 20% engine power, while the doors are closing.

When the doors have closed, engine power can be increased by further rearward movement of the reverse thrust lever.

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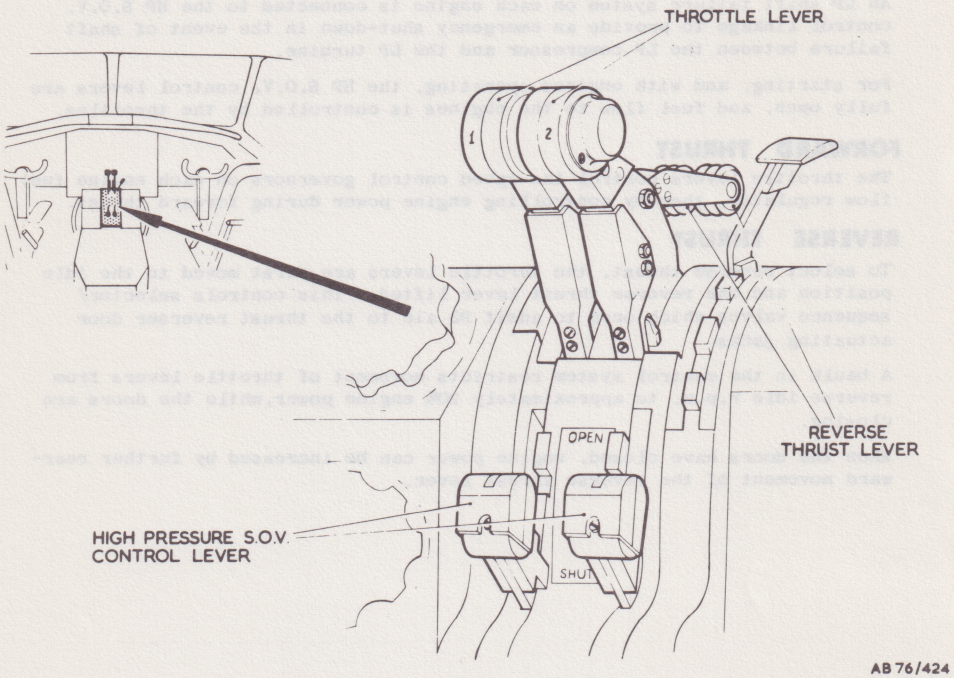

Typical Controls
Figure 1

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EXHAUST

General

The exhaust system, consisting of a thrust reverser and an integral exhaust collector and propelling nozzle, passes the engine gas efflux to atmosphere in a rearward or forward direction under manual control. HP compressor outlet air (P3) to actuate the thrust reverser rams is taken from a tapping at the bottom right-hand side of the fuel heater tube.

Reverse thrust is selected, by moving the throttle levers to the idle r.p.m. position and lifting the reverse thrust levers. In this position movement of the reverse thrust levers is restricted to approximately 20% of engine power, until the reverser doors close across the exhaust unit and further movement of the levers increases engine power.

Thrust reverser assemblies are made interchangeable by rotating through 180 degrees and 'handing' the associated equipment.

THRUST REVERSER

The thrust reverser is attached to the engine exhaust mixer, and when reverse thrust is selected, two clamshell doors close the jet pipe and deflect the exhaust gas stream forward, through cascade vanes, above and below the engine pods thus providing an effective brake.

In forward thrust the outlet to the cascade vanes are closed by the doors which now fit flush with the exhaust collector inner wall to discharge the gas stream directly aft.

COLLECTOR/PROPELLING NOZZLE

The collector is a tubular structure of heat resisting steel sheet and forms an integral exhaust collector and propelling nozzle. A circumferential manifold welded to the outside of the collector forms a mounting ring for nine equally spaced, forward facing probes which project into the collector. The probes, through the manifold, connect engine exhaust pressure (P7) to an indicating system measuring exhaust absolute pressure.

The collector ducts the exhaust gas rearward from the thrust reverser to the convergent section of the propelling nozzle. The exhaust gas pressure energy is converted into velocity in the throat and the divergent after-section of the nozzle, so that the gas is finally discharged to atmosphere at high velocity and approximate ambient pressure.

The thrust produced is a function of the exhaust collector (P7) ambient air pressure (PO) and the cross-sectional area of the nozzle end.

The collector is interchangeable with left and right-hand engines by rotation through 180 deg., to 'hand' the indicating system union connection.

Some aircraft are equipped with longer collectors which are acoustically lined and terminate in a fluted nozzle, the principle being to substantially increase the 'wet' area and so reduce noise emission. The nozzles form part of the 'hush kit' which also includes acoustically lined nacelle nose cowls (see Section 3-2-0).

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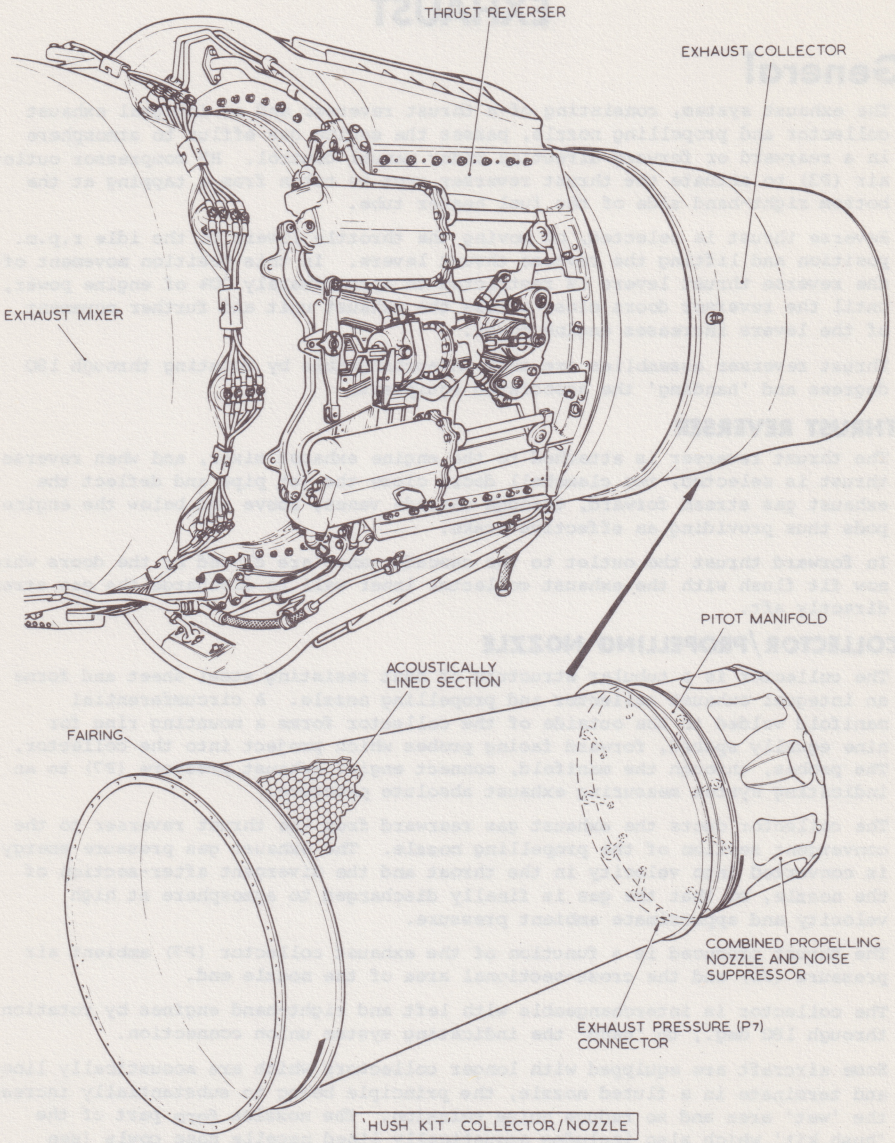

G.A. of Exhaust Section
Figure 1

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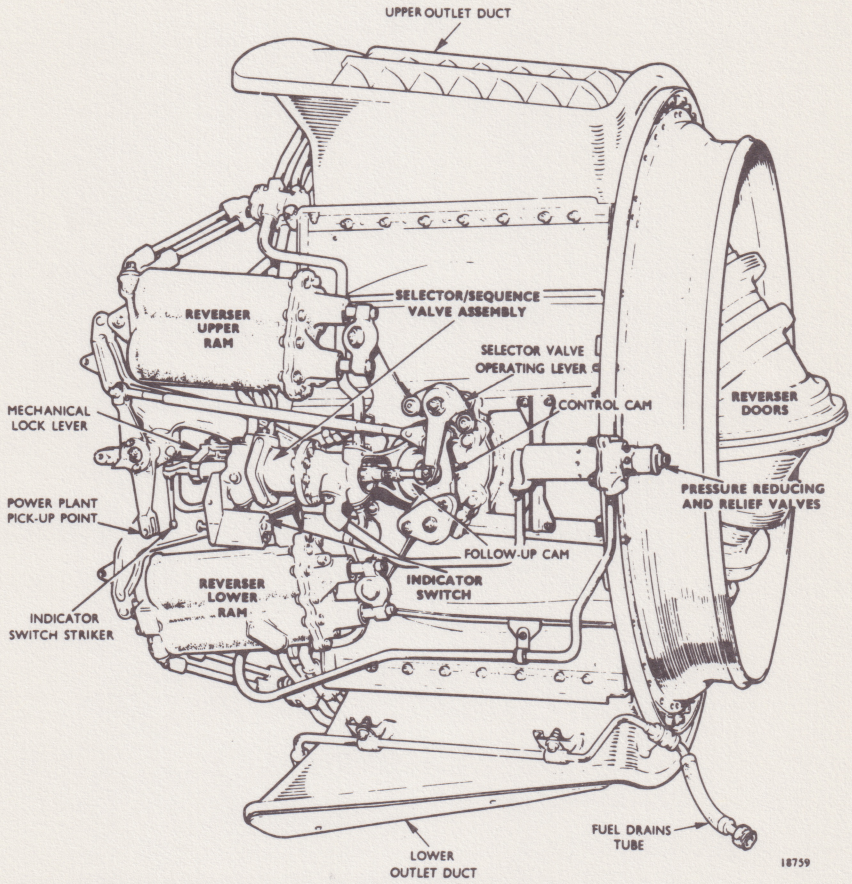

Thrust Reverser
Figure 2

WATER INJECTION

The water injection system is installed in aircraft with the 'wet' (Spey 512-14DW) engine.

During take-off under high ambient temperature conditions and/or high altitude airfields, engine thrust is impaired by the reduction of mass air flow through the engine.

By injecting a controlled flow of water, proportionate to fuel flow into the combustion liners, power is restored to approximately sea level I.S.A.

Water is supplied to both engine systems from a common storage tank,. A turbine pump circulates the water through a series of non-return valves, a water flow sensing unit and a fuel flow regulator/HP governor reset.

An high-pressure air system with associated valves combine to operate the water system.

With the engines running and the system master switch set to ON the circuits to the throttle-operated micro-switches of each engine are closed. On opening the throttles beyond the max. continuous settings, the micro-switches close and complete a circuit via the low-level float switches to shut the pressure reducing shut-off valves, closing the air ducts to aircraft services, except that from the APU.

A parallel circuit is completed to energize the air valves, allowing them to be opened by HP air and cause the air valve indicator lamps to light.

HP (P3) air delivery to the turbine pump, controlled by non-return valves downstream of the air shut-off valves, accelerates the turbine. The increased water pressure opens a non-return valve and valve ports in the water sensing units, to direct a controlled flow of water to the engine combustion chamber. Simultaneously the HP governor reset mechanism, embodied in the fuel flow regulator, proportionally increases the flow of fuel to the combustion liners, where the water and fuel mix on emerging from the spray nozzles. As the sensing units open the valve ports, water flow indicating lamps on the centre instrument panel come on.

When the throttles are moved back through the max. continuous settings, or if the tank low-level switches operate, the air valves shut off the supply and the associated indicating lamps go out. The water flow indicating lamps go out when the water sensing units supply ports close and the flow ceases.

With the termination of water injection, the selection of DRAIN on the master switch, opens the flight drain valve, and allows residual water in the tank to drain overboard and causes the drain valve indicator to register OPEN.

When OFF is selected, the drain valve closes and the indicator registers CLOSED.

Should one engine or its H.P. air fail on a wet take-off this would result in water injection cancellation to that engine only.

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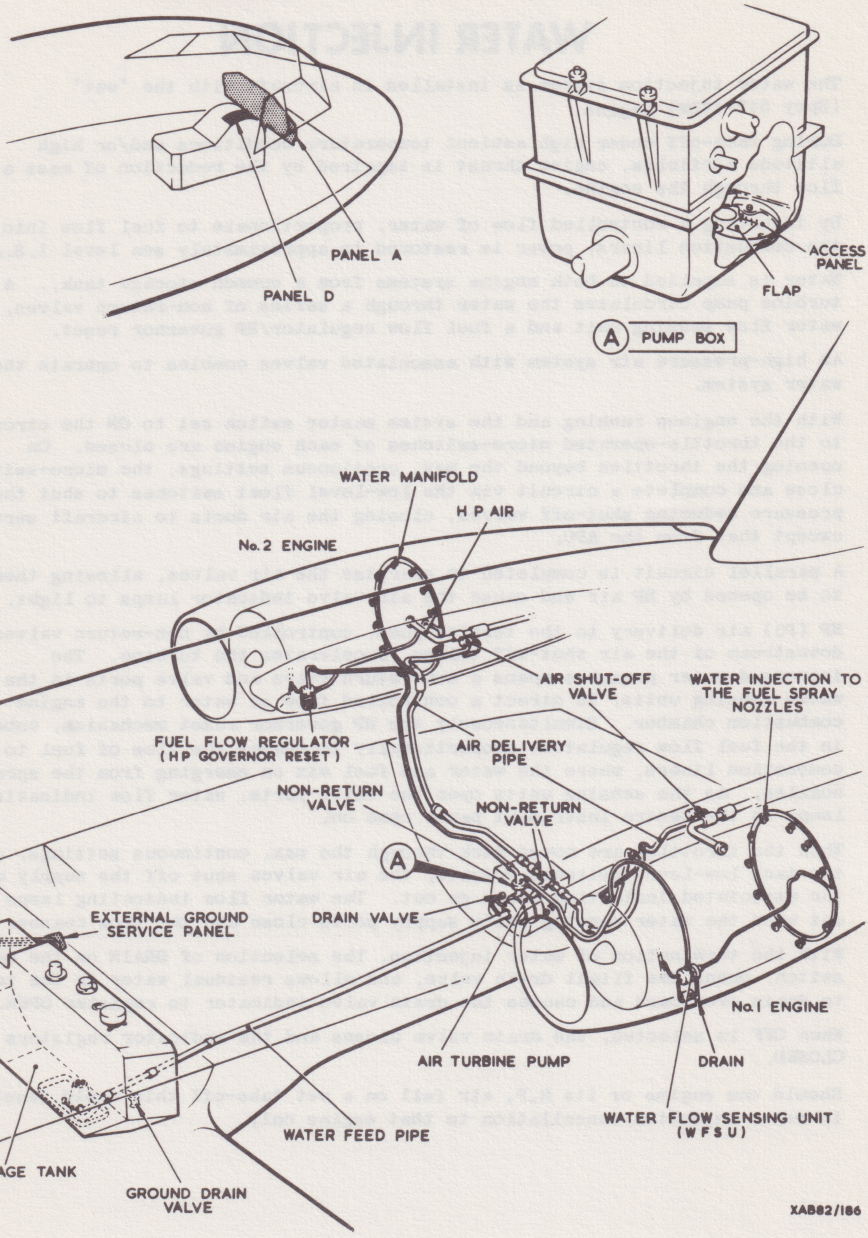

G.A. of Water Injection System
Figure 1

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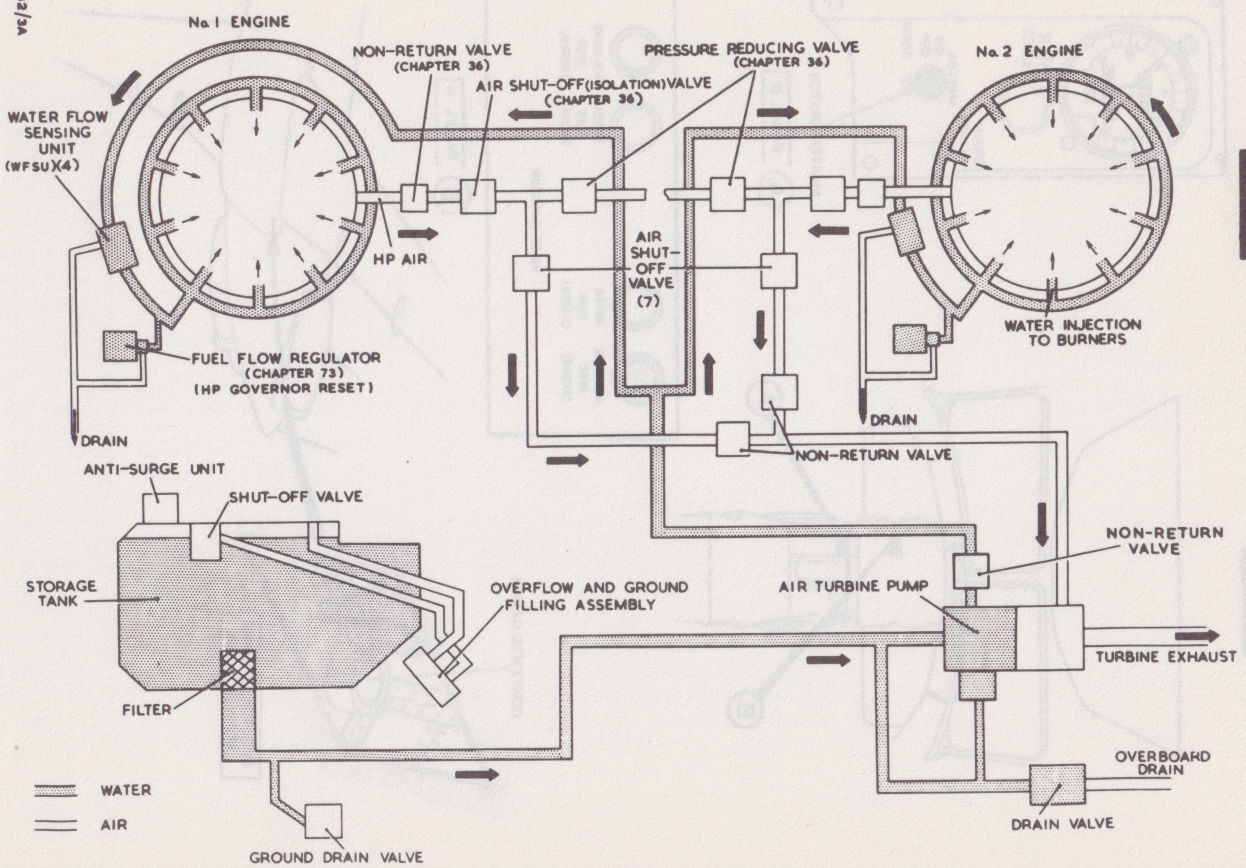
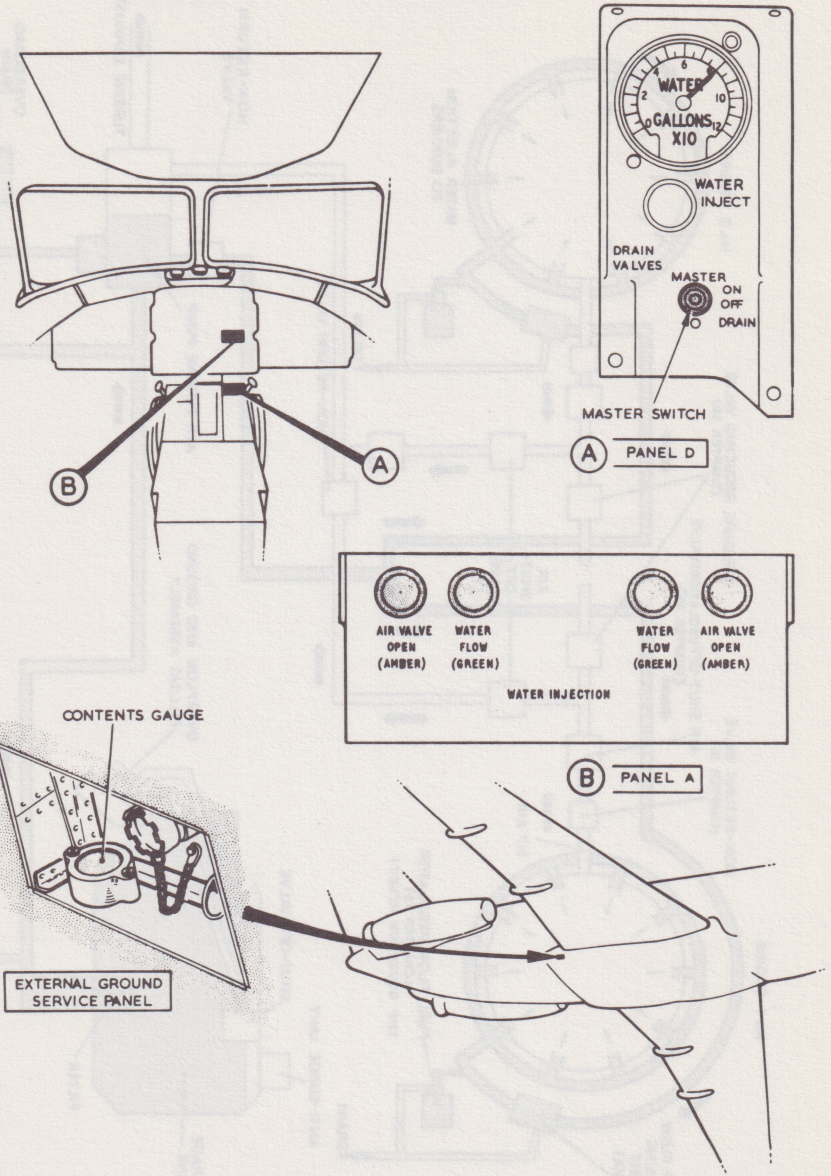


Distribution Diagram
Figure 2



Controls and Indicators
Figure 3

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WATER INJECTION - SERVICING

General

The system must be replenished in accordance with flight requirements i.e., before take-off from a 'hot and high' airfield.

Draining can be achieved via the drain valve in the underwing fairing.

For servicing of the domestic water system see Section 2-16-0.

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FILLING

NOTE: Use only DEMINERALISED WATER Spec.AEP/W.

A. Normal

1. Connect a water charging rig, via an Avimo mk.11-1-50A8 adapter, to the replenishing coupling.
2. Replenish at a MAX. pressure of 35 p.s.i. until full i.e. 110 Imp. gallons (132 U.S.gallons, 500 litres).
3. Allow surplus water to drain before replacing the dust cap and closing the servicing box door.

B. On some aircraft the water replenishment rig is activated by air under pressure from the APU.

1. Connect the replenishment unit air pipe to the AIR SUPPLY connection on the hydraulic service panel and the water hose to the replenishing coupling.
2. Insert the suction pipe into water container.
3. Check that the fan isolation switch on panel B is at ISOLATE.
4. Start the APU and open the air delivery and crossfeed valves.
5. Fill the water tank at a MAX delivery pressure of 35 p.s.i.

   CAUTION: DO NOT ALLOW THE REPLENISHMENT UNIT TO RUN DRY.

6. Check the tank contents on the contents gauges. This should not exceed the nominal capacity of the tank.
7. Close the APU delivery valve and stop the APU.
8. Check that there is no flow from the overflow outlet then disconnect the replenishing hose and refit the dust cap.
9. Disconnect the air hose and refit the blanking cap.

   CAUTION: ENSURE THAT THE BLANKING CAP IS SECURELY FITTED.

10. Close the access doors.

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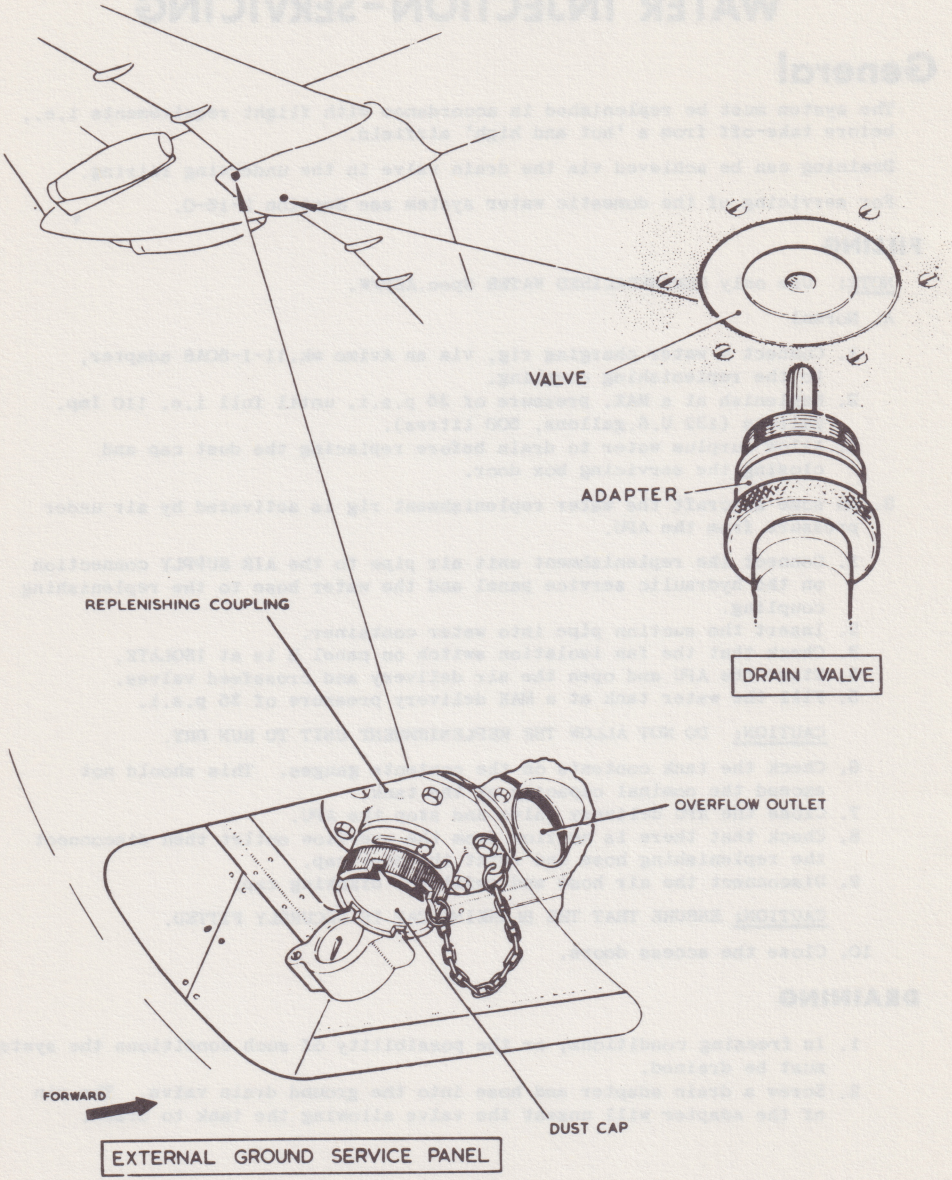
DRAINING

1. In freezing conditions, or the possibility of such conditions the system must be drained.
2. Screw a drain adapter and hose into the ground drain valve. The pin of the adapter will unseat the valve allowing the tank to drain.



Water Injection Filling and (Ground) Drain Points
Figure 101

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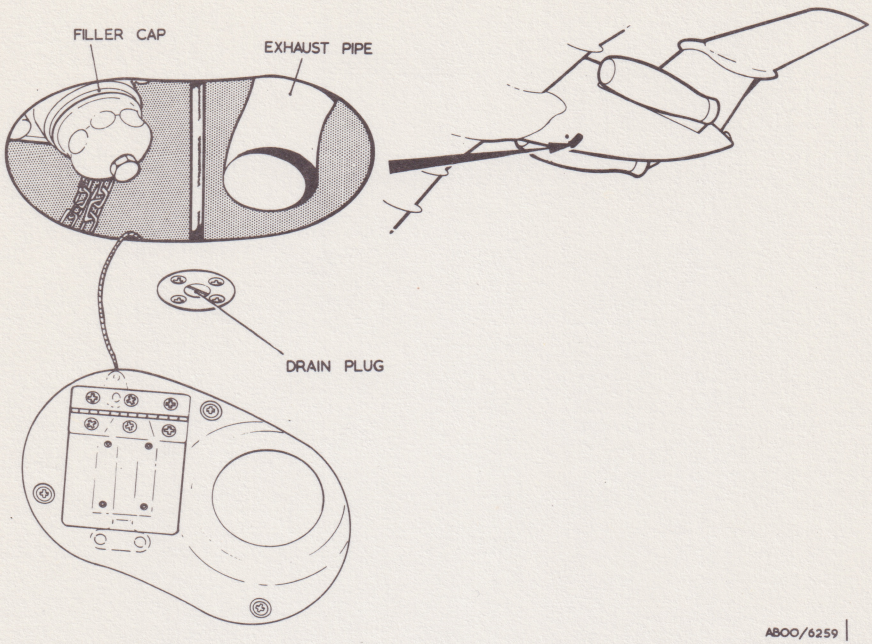

Water Injection Turbine Pump Oil Filling Point
Figure 102

APPROVED OILS

3 CENTISTOKE		5 CENTISTOKE (TYPE 11)			
Castrol	Aeroshell	Esso	Mobil	Chevron	Caltex
3C	Turbo 390	Turbo 2380	Jet 11	Jet 5	RPM Jet 5

It is recommended that different proprietary brands are not intermixed.

CAPACITY

0.74 U.K. pints	0.89 U.S. pints	420 c.c.

OIL REPLENISHING

1. Remove the access panel F3-40 and the oil filler connector cap.
2. Screw out the drain plug.
3. Pressure fill until oil begins to run out of the drain.
4. Replace the oil filler cap, screw in and tighten the drain plug.
5. Wipe away spilt oil and replace the access panel.

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CONSTANT SPEED DRIVE AND STARTER (C.S.D.S.)

The CSDS, fitted to the right-hand gearbox of each engine, provides a starting mechanism and a constant speed drive from the engine HP compressor shaft to the aircraft generator. A pneumatically operated clutch in the gearbox permits disengagement of the drive in the event of engine or unit failure, or overspeeding.

When supplied with air, a reversible air motor provides the source of power for engine starting, and a means of controlling the power output to the generator during constant speeding. An air control valve (ACV), actuated by a pump and governor unit, controls the flow of air through the motor. A pressure regulating valve, mounted on the ACV, controls the HP compressor bleed air at the specified rate.

The output speed of an epicyclic differential gear is a function of the input speeds. The inputs to the CSDS differential are the engine and the air motor. As the air motor is controlled by an hydraulic/pneumatic control system, the final drive, from the CSDS to the generator, can be maintained at constant speed by controlling the speed of the air motor to compensate for varying engine speeds.

Engine Starting

Air is fed, via the engine delivery duct, to the upstream side of the PRV. When the 'open' coil of the start valve solenoid is energized the valve operates and allows upstream air pressure to the PRV datum chamber. The PRV opens and admits air, through the ACV, to the air motor.

The resultant drive is transmitted to the sprag clutch and to the planet carrier of the differential, the sprag clutch engages and drives the output shaft. This double input to the differential automatically provides an overall fixed speed ratio between the air motor and the engine, and the air motor and the generator.

After engine light-up, the engine will accelerate, partly under its own power and partly due to the torque applied by the CSDS until the generator reaches its synchronous speed of 6,000 r.p.m. At this point, the air motor drive shaft and the sprag gear will both be rotating in the same direction at 12,000 r.p.m. This will occur at an engine HP compressor speed of approximately 5,000 r.p.m.

Constant-Speed Drive - Low Engine Speed

As the engine accelerates, the governor unit supplies an increased oil flow to the ACV actuator. The resultant pressure rise across the actuator causes the ACV piston to move and reduce the air supply to the air motor, decreasing the air motor speed. The air motor input to the differential gear reduces in proportion to the increased engine input, and the generator speed remains constant. The sprag clutch, rotating at a higher speed than the air motor drive shaft, disengages, and the CSDS begins its constant-speed drive function. Air is now supplied to the air motor in sufficient volume and pressure to balance the friction and inertia torques of the generator.

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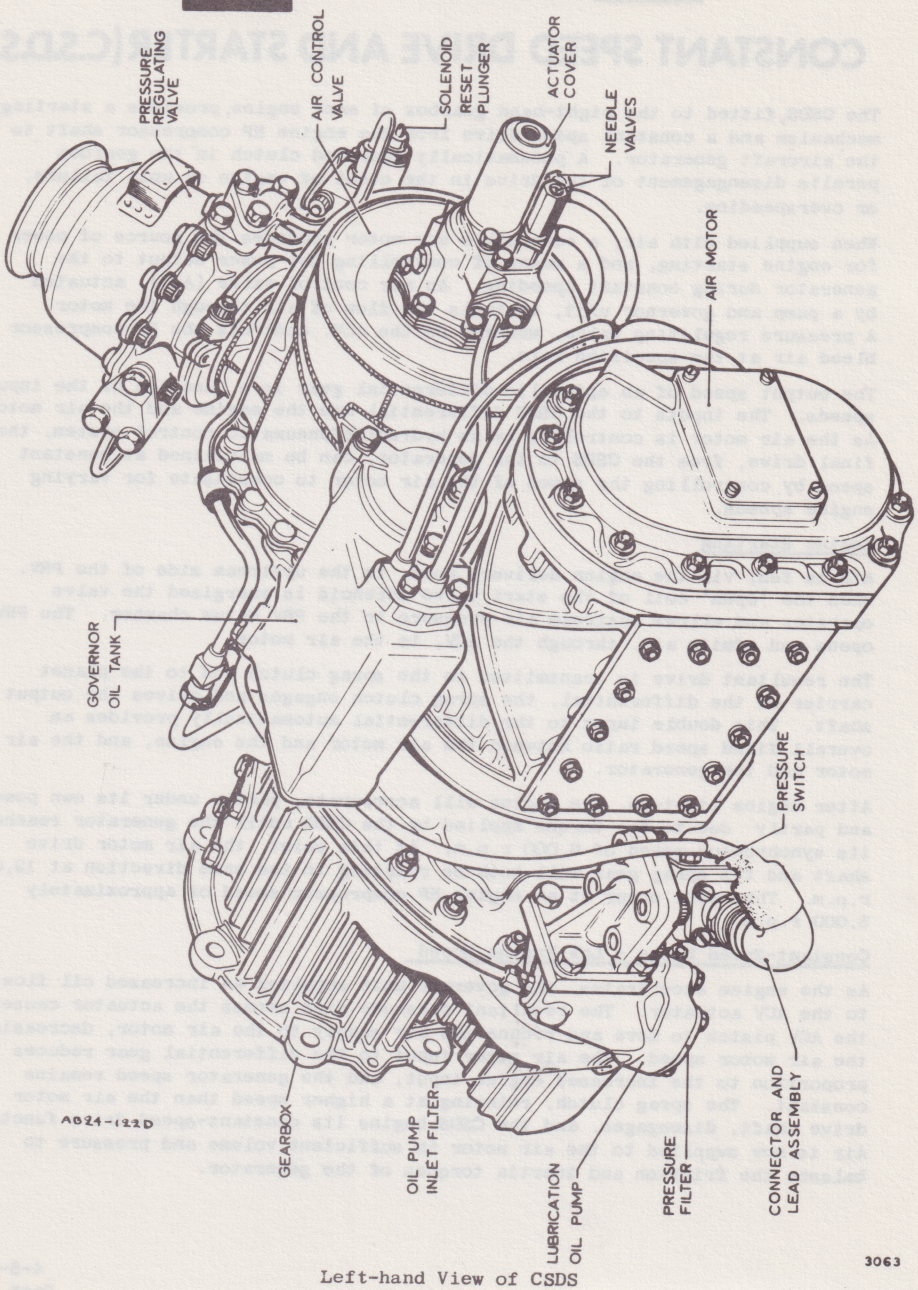

Left-hand View of CSDS

Figure 1

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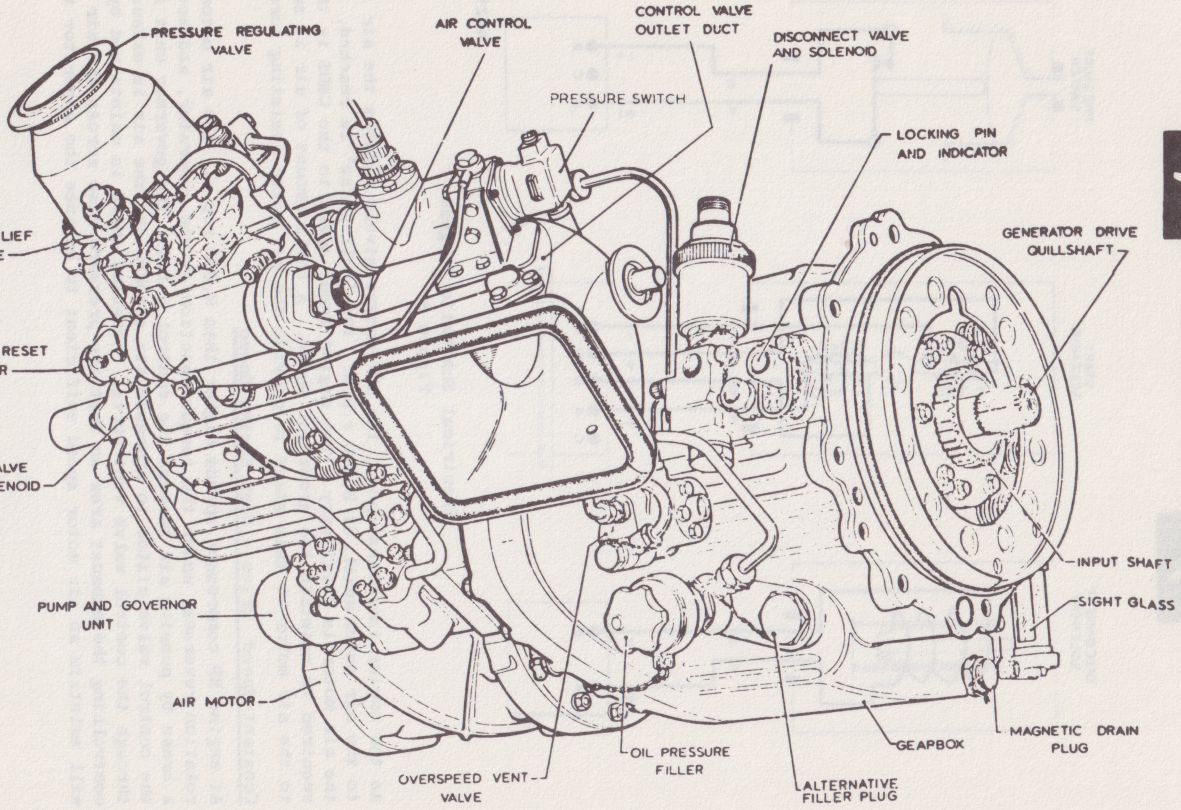
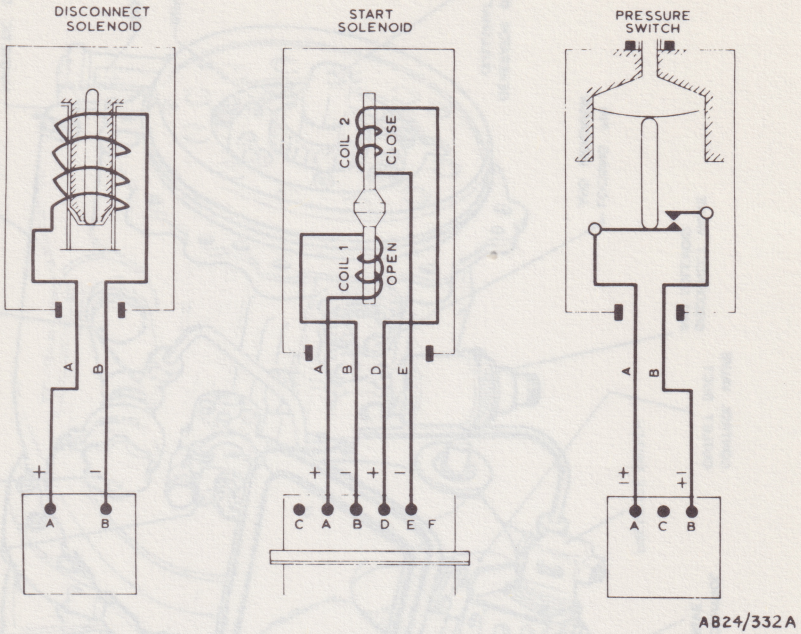


Right-hand View of CSDS
Figure 2



Electrical Schematic Diagram
Figure 3

As the engine increases speed, the ACV progressively reduces the air supply to the air motor until, at 9,200 r.p.m., the 'null point' is reached, i.e., the air motor is stationary. The engine input speed to the CSDS is that required to maintain the generator speed. A small amount of air is supplied to the air motor at this stage to provide the air motor resisting torque.

Constant-Speed Drive - High Engine Speed

At engine HP compressor speeds higher than 9,200 r.p.m., the air motor rotation reverses, under the torque reaction of the generator, and acts as a brake by pumping air through the control valve. The governor unit signals the control valve piston to increase its stroke, and the air is exhausted through the control valve vent ports. Constant speed is maintained by controlling the exhaust area so that the pressure rise across the air motor will maintain an air motor speed sufficient to balance the generator torque.

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Constant-Speed Drive - High Engine Speed, Light Electrical Load

At very high speed and light electrical load, the pressure rise across the air motor may be excessive, causing the air motor speed to reduce. To avoid the resulting increased generator speed, extreme movement of the control valve piston uncovers ports which admit air from the engine delivery duct and allow it to escape through the ejector nozzles. This assists the flow of air through the air motor and maintains constant speed.

Engine Shut-down

As the engine speed is reduced to idling, the hydraulic control system restores the CSDS to below 'null' condition.

When the engine is shut down, the 'closed' coil of the start valve solenoid is automatically energized. The start valve cuts off the air supply to the PRV and vents the PRV datum pressure, causing the PRV to close and shut off the air to the air motor. During engine run-down, the pump and governor unit, assisted by the return spring, restores the ACV piston to the start position.

CSDS Disconnect - Manual Selection

When CSDS disconnect is selected, the disconnect solenoid and the 'close' coil of the start valve solenoid are energized.

The disconnect ball valve is unseated and admits PRV inlet air pressure through the transfer valve to the disconnect piston chamber. The piston and actuator move, causing the rocker arms to disengage from the coupling. Simultaneously, the start valve vents the PRV datum chamber and the PRV closes, shutting off the air supply to the air motor. A combined locking pin and position indicator locks the piston in the disengaged position and prevents re-engagement of the mechanism in flight.

CSDS Disconnect - Overspeeding

In the event of the generator speed exceeding the specified limit, the overspeed control mechanism will operate and actuate the overspeed vent valve. Both poppet valves will open and allow air pressure through the transfer valve to the disconnect piston chamber, simultaneously venting the PRV datum chamber.

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C.S.D.S. - SERVICING

General

The CSDS oil system is self-contained and is replenished through a pressure filler connection mounted on the gearbox, or gravity filled through an adjacent plugged orifice. A sight glass indicates the oil level. Oil is returned by gravity to the sump, where a magnetic chip detector, embodied in the sump drain plug, collect particles of metal that may be released into the oil system.

All sealing rings and gaskets, distrubed during servicing, must be renewed.

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APPROVED OILS

3 CENTISTOKE		5 CENTISTOKE (TYPE 11)		
Castrol	Aeroshell	Esso	Mobil	Texaco
3C	Turbo 390	Turbo 15	Jet 11	TL 5180
325		Turbo 2380		TL 6256
		Turbo 5251		

It is recommended that different proprietary brands are not intermixed.

CAPACITY (APPROX)

4.3 Imp. Pints 5.1 U.S. pints 2.46 litres

~~Max. permissible/hr. 15 cc~~

SPECIAL TOOLS

ITEM	PART NO.	DESCRIPTION
1	T.404670/39	Spanner, for removing/ installing the oil pump inlet filter.
2	TL.61468	Oil draining tool

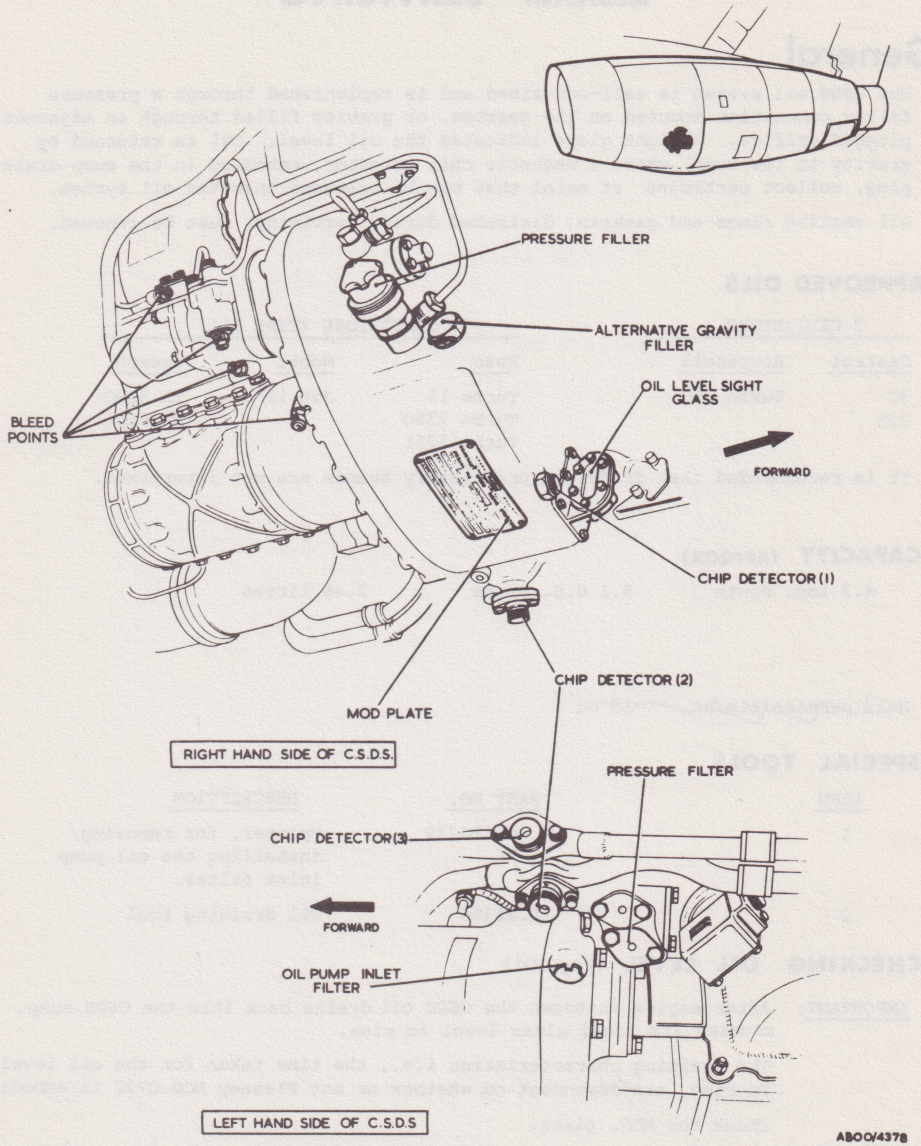
CHECKING OIL LEVEL (Fig 101)

IMPORTANT: After engine shutdown the CSDS oil drains back into the CSDS sump, causing its sight glass level to rise.

The draining characteristics i.e., the time taken for the oil level to rise, are dependant on whether or not Plessey MOD.C721 is embodied.

Check the MOD. plate.

It is essential that the following be observed to avoid overfilling or underfilling.



C.S.D.S. Oil System Servicing Points
Figure 101

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The oil level can be considered satisfactory when:-

MOD.STATE	CHECKED	READING
C.721 not embodied	Within 10 min shutdown	$\frac{7}{8}$
C.721 not embodied	More than 10 min. after shutdown	FULL
C.721 embodied	Within 60 min.shutdown	$\frac{7}{8}$ to FULL
C.826 and C.916	Within 10 min.shutdown	Midway between FILL and FULL

When C.721 is embodied, the check MUST be within the 60-minute period. On such units, where the oil level is noted to rise above FULL subsequent to the 60-minute period, DO NOT DRAIN; this rise is unlikely to be due to an over-fill condition, but to protracted draining as previously explained. If in doubt, run or motor the engine and re-check within the 60-minute period specified.

REPLENISHING / FILLING (Fig.101)

CAUTION: AVOIDANCE OR UNDERFILLING AND OVERFILLING IS EQUALLY IMPORTANT.

1. Pressure or gravity-fill if required, (see 'Checking Oil Level').

   If pressure-filling, limit delivery pressure to 100 p.s.i.

2. When refilling from empty, e.g., after inspection of filters, etc., bleed the system via the four bleedscrews provided. Bleed with $\frac{3}{4}$ reading on sight-glass; allow 10 minutes for oil to settle, then top-up to FULL.

DRAINING (Fig.101)

The unit may be completely drained of oil by removing the magnetic chip detector, and inserting the special drain tool (see page 101).

PRESSURE FILTER (Fig.101)

The filter element should be removed during periodic checks, or when the condition of the CSDS is suspect, and examined for deposit of metal particles.

Wash the element with Ardrox 1618 fluid, thoroughly rinse in clean water, dry with clean compressed air and immerse in clean gearbox oil before refitting. Torque-tighten bolts to 40 lb.in.

If metal deposits were found, they must be submitted for analysis.

Small deposits of light-alloy are permissible, but coarse particles of metal, particularly bronze or steel, entails rejection of the CSDS. The particles must be wrapped, labelled and returned, with the CSDS to an overhaul base.

Where fine particles of bronze or steel are present, clean and replace the filter, replenish the oil system, then run the CSDS through the whole engine speed range. Re-examine the pressure filter. Removal and examination of the oil inlet filter and chip detector/drain plug may provide additional evidence for suspected internal failure.

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OIL PUMP INLET FILTER (Fig. 101)

Remarks as for 'Pressure Filter' above, except for the following:-

1. Unscrew to remove, using special tool (see page 101).

2. Wash with KEROSINE: dry and oil-immerse before refitting.

MAGNETIC CHIP DETECTORS (Fig. 101)

The chip detectors attract and retain small particles of steel released into the system, and thus provide, on inspection, early warning of bearing failure.

Removal is simple, the detector being bayonet-coupled, and its orifice is self-sealing to allow inspection without draining.

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GROUND RUNNING

General

Ground running will be necessary following engine installation, replacement of any unit likely to affect the operation of a system or engine performance, and to prove adjustments or confirm inconclusive engine fault reports.

It is of vital importance that during the preparation, starting and running sequences, all safety precautions and steps of procedure are strictly observed.

ESSENTIALLY, LEARN THE GROUND OPERATING LIMITATIONS

STARTING METHODS

Each engine is rotated for starting by an air input to its CSDS; this is normally taken from the APU but can be from an external source through a ground connection under the right nacelle stub (Fig.3).

With one engine running, the other may be started by cross-feeding air from the running engine.

When both engines are to be run, either may be started first; the order of starting does however determine the required cross-feed valve settings.

TAIL-WIND STARTS should be avoided since a 'hot' start is likely to result, due to initial reverse-rotation 'windmilling' of the rotors.

When a tail-wind start is unavoidable, the HP fuel valve should be opened immediately correct LP compressor rotation is indicated.

ICING CONDITIONS

Engine anti-icing should be used when icing is indicated by the aircraft detector system, or when dry bulb ambient air temperature is below + 8 deg. C, wet bulb temperature below + 4 deg. C and visible moisture present such as rain, sleet, snow, fog, hail or wet runways. It should be switched on immediately engine has reached idling speed.

CREW

Minimum personnel for a normal (APU-induced) start is three, as follows:-

One (in charge) suitably sited on ground clear of danger areas and able to view nacelle.

One on flight deck (brakes, engine and fuel controls).

One at side of nacelle, manning ground fire-fighting equipment.

The Engineer-in-charge should be intercomm-linked to engineer on flight deck.

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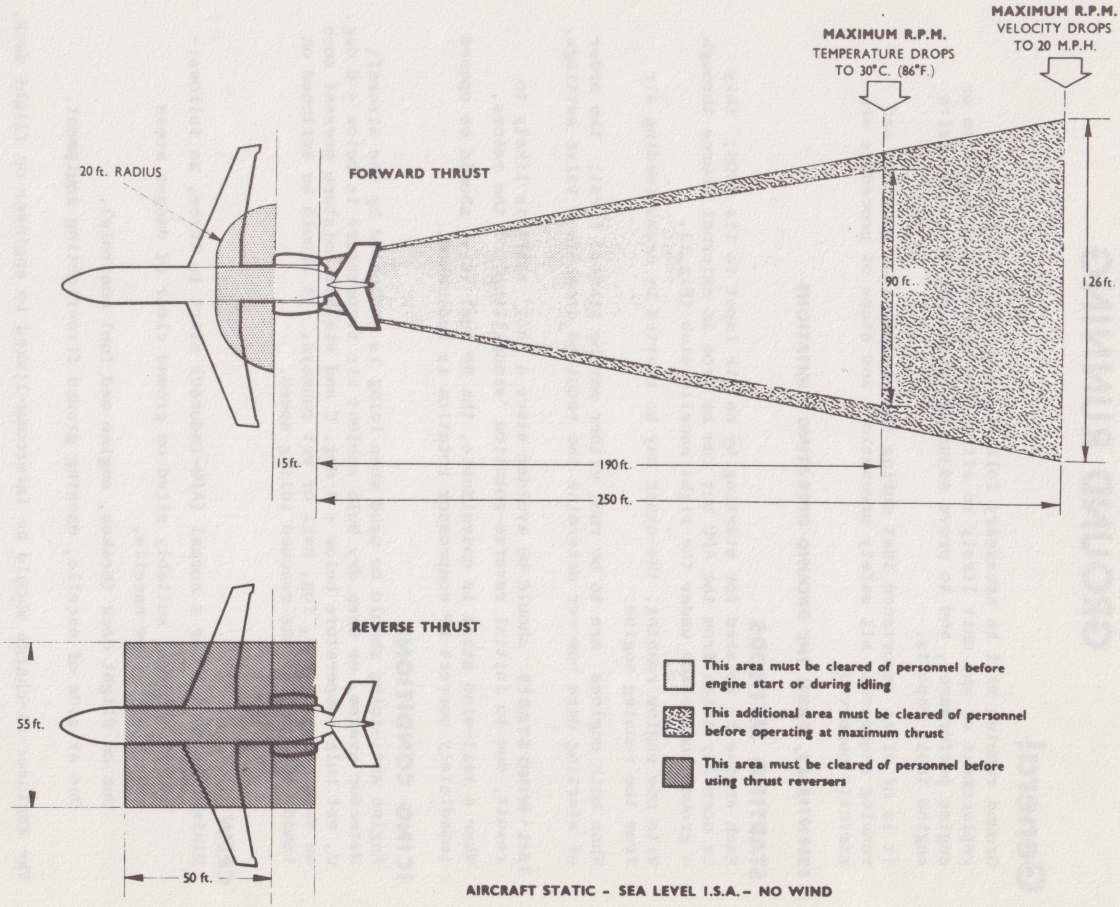

Blast Areas
Figure 1

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GROUND OPERATING LIMITATIONS

CONDITION	% R.P.M.		MAX.TGT deg.C	TIME LIMIT
	HP	LP		
During start	-	-	600 (See note below)	2 seconds
Max. continuous	99.5	107.2	560	Unrestricted
Max. take-off				
Dry	101.9	107.2	600	5 minutes
Wet	103.1	107.2	610	5 minutes
Ground idling	59 to 62	-	560	Unrestricted
Max. with reverse thrust	101.9	107.2	590	30 secs.
Max. overspeed	106.2	110.4	-	20 secs.
Max. with ISOL VALVE open	Above 80	-	-	2 minutes
Max. with ISOL VALVE closed	Above 80	-	-	5 minutes

NOTE: Under normal starting conditions (-10 deg.C to + 30 deg.C indicated engine fuel temperature) and satisfactory engine performance, the maximum TGT to be expected during starts is 520 deg.C.

Temperature in excess of this figure is indicative of a fault on either the engine or aircraft starting systems and should be investigated.

LUBRICATION SYSTEM

Minimum at idling	22 p.s.i.
Normal at max.continuous r.p.m.	40 to 55 p.s.i.
Minimum acceptance for flight at take-off r.p.m.	40 p.s.i.

OIL TEMPERATURES

Minimum for starting	Minus 40 deg. C.
Minimum for opening up	Minus 40 deg. C.
Maximum (unrestricted)	Plus 100 deg. C.

FUEL TEMPERATURES

Maximum at HP pump inlet 15 mins. Plus 110 deg. C.

PREPARATION FOR STARTING

1. Position the aircraft clear of buildings and other aircraft, taking account of blast areas (Fig.1) and headed into wind (See note on TAIL-WIND STARTS).
2. Centralize nosewheels, chock all wheels, apply parking brake and ensure that all landing gear ground locks are fitted.

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3. If engine is to be accelerated past idling r.p.m. with reverse thrust selected, disconnect the control rod and fit locking tool (Part No.AB94A6735) as shown on Fig.2. Support the rod to allow it free movement when reverse thrust is selected.

4. Close and fasten all cowlings, except those required open for adjustments or inspection while running. If reverse thrust control rod has been disconnected, ensure that locking tool pennant is clearly visible.

5. Clear ground area around engine, of all debris and loose equipment.

6. Remove intake and exhaust blanks, check that:

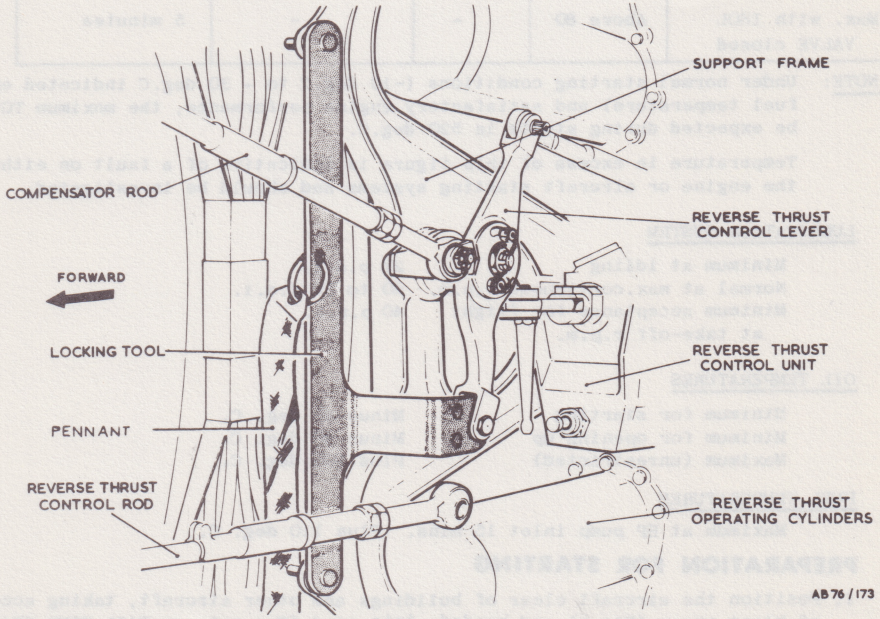
   Compressor intake guide vanes are undamaged and, in icing conditions, free of ice.

   Thrust reverser is in forward thrust position.

   LP compressor is free to rotate.

   HP air duct blow-out plug, under nacelle stub, is not protruding.

   Fuel drain tank vent, under nacelle, is unobstructed.



Thrust Reverser Locking
Figure 2

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7. Position ground fire-fighting (CO_2) equipment at side of nacelle.

8. Start and run the APU (1-9-2) or connect an external air start supply line to the ground connection (Fig.3).

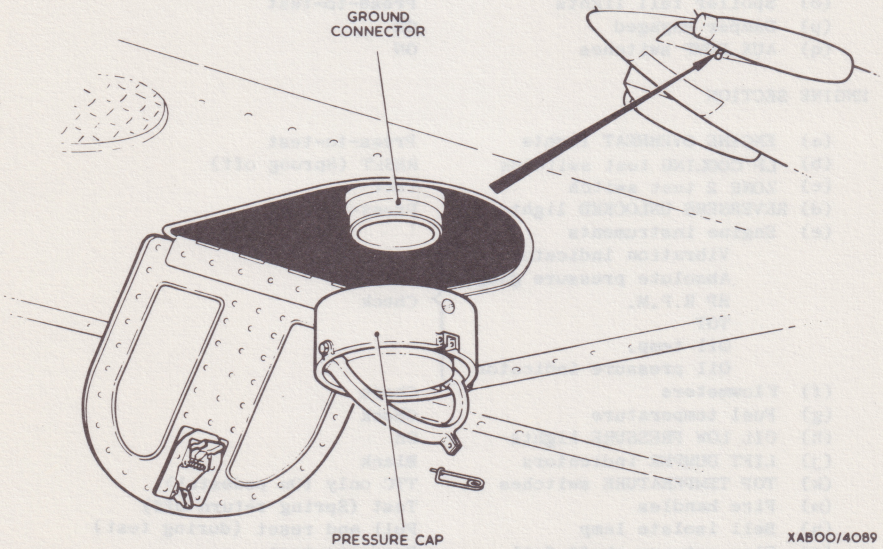
9. Carry out the following INTERIOR CHECKS in detailed sequence.

ON FLIGHT DECK (GENERAL)

(a)	Brakes	Park
(b)	Flaps	UP
(c)	Landing gear selector	DOWN
(d)	GEAR lights	3 green
(e)	GEAR UNSAFE indicator	Out
(f)	MASTER WARNING light	On

PEDESTAL

(a)	Throttles	Close
(b)	HP SOV levers	SHUT
(c)	Engine Top Temp.Control	TTC ONLY
(d)	WATER INJECT contents gauge	As required
(e)	Master switch	OFF



External Air Start Connection
Figure 3

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ON CENTRE INSTRUMENT PANEL

FUEL SECTION

(a)	Contents gauges	Check (operate test-push)
(b)	Temperature gauge	Check
(c)	Totalizer	Check (if fitted)

HYDRAULIC SECTION

(a)	Brake pressure (Foot)	Check (2,800 p.s.i. nominal)
(b)	Brake pressure (Hand)	Check (3,000 p.s.i. nominal)
(c)	Brake accumulator	Check (3,000 p.s.i.)
(d)	DC PUMP switch	OFF
(e)	AC PUMP switch	OFF
(f)	ENG PUMP switches	ON
(g)	O/HEAT warning lights	Press-to-test
(h)	FAIL warning lights	On
(j)	PUMP MOTOR O/HEAT warning lights	Press-to-test
(k)	System pressure gauge	Check
(m)	System contents gauge	Check
(n)	Spoiler switches	ON
(o)	Spoiler fail lights	Press-to-test
(p)	Damper engaged	ON
(q)	AUX PUMP switches	ON

ENGINE SECTION

(a)	ENGINE OVERHEAT lights	Press-to-test
(b)	LP COOLING test switches	RESET (Sprung off)
(c)	ZONE 2 test switch	TEST
(d)	REVERSERS UNLOCKED lights	Press-to-test
(e)	Engine instruments	
	Vibration indicators	Check
	Absolute pressure gauges	
	HP R.P.M.	
	TGT	
	Oil temp.	
	Oil pressure indicator	
(f)	Flowmeters	Check
(g)	Fuel temperature	Check
(h)	OIL LOW PRESSURE lights	On
(j)	LIFT DUMPER indicators	Black
(k)	TOP TEMPERATURE switches	TTC only (On pedestal)
(m)	Fire handles	Test (Spring return off)
(n)	Bell isolate lamp	Pull and reset (during test)
(o)	Flap primary shaft fail	Press-to-test
(p)	Horn cut-off	Test
(q)	GEAR lights dimmer switch	Bright
(r)	TOTAL AIR TEMPERATURE	Check

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(t)	Mach trim	Press-to-test or ON (as fitted)
(u)	FLAP indicator: Tail trim indicator, Elevator trim indicator	Check
(v)	Ram air valve	CLOSE
(w)	Safety valve	OPEN

ON ROOF CENTRE PANEL

ELECTRICAL SYSTEM SECTION

(a)	CSD FAIL warning lights	On
(b)	Generator disconnect switches	Normal
(c)	GEN FAIL warning lights	On
(d)	GEN CONTROL switches	RESET
(e)	BUS FAIL	Press-to-test.
(f)	FREQUENCY meter	Check APU Select generator being started
(g)	AC VOLTS	Check (115V)
(h)	DC VOLTS	Check - push for battery volts
(j)	BATTERY MASTER switch	ON
(k)	DC FAIL light	Press-to-test
(m)	Battery indicator	On
(n)	KVA meter	Check
(o)	TRU AMPS	Check
(p)	BATTERY AMPS	Check

FUEL SECTION

(a)	BOOSTER PUMPS switches	OFF
(b)	BOOSTER PUMP LP lights	On
(c)	LP VALVE switches	OPEN (Indicator in-line)
(d)	CROSSFEED VALVE switch	CLOSE (Indicator X-line)
(e)	ENGINE LOW PRESSURE lights	On
(f)	TRANSFER PUMPS switches	OFF (If fitted)
(g)	TRANSFER VALVE switches	CLOSE (Indicator X line) (If fitted)
(h)	TRANSFER LP light	Press-to-test (If fitted)
(j)	PUMP DEFUEL amber light	OFF

APU SECTION

(a)	APU CONTROL switch	OFF
(b)	FUEL VALVE indicator	CLOSED
(c)	AIR DELIV VALVE switch	CLOSE If on ground supply
(d)	AIR CROSSFEED VALVE switch	CLOSE
(e)	AIR CROSSFEED VALVE indicator	CLOSED
(f)	APU FIRE switch	AUTO (when flt.deck unattended If MANUAL (otherwise) fitted
(g)	OIL LP light	OFF

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AIR SYSTEM SECTION

(a) SYSTEM FAIL indicators	OFF (If APU running)
(b) ISOLN VALVE switches	As required
(c) MASTFR VALVE switches	As required
(d) MASTER VALVE warning lights	Press-to-test
(e) STUB DUCT FAIL	Press-to-test and reset
(f) FUSELAGE DUCT FAIL	Press-to-test (Both SYSTEM FAIL lights to come on)
(g) TEMP SELECTION	As required

DOORS SECTION

(a) DOOR WARNING lights	Out (doors closed) Press-to-test

STARTING SECTION

(a) LP SHAFT ROTATION light	Press-to-test
(b) START MASTER switch	OFF
(c) Start selector switches	OFF
(d) IGNITER ON lights	Press-to-test
(e) LP RPM indicators	Check-off-scale

ANTI-ICE SYSTEM SECTION

(a) All switches (4 airframe (2 engines	OFF
(b) Pressure indicators	± 5 p.s.i. from zero
(c) TEMP indicator	Check
(d) WINDSHIELD OVERHEAT	Press-to-test
(e) WINDSHIELD UNDERHEAT	Press-to-test
(f) WINDSHIELD HEAT switch	OFF
(g) SIDE WINDOW HEAT SWITCH	OFF
(h) ICE WARNING	OFF
(k) VISUAL ICE INDICATOR	OFF

WATER INJECTION

(a) Contents gauge	As required
(b) MASTER switch	OFF
(c) DRAIN VALVE indicator	Closed
(d) AIR VALVE OPEN indicator light	Press-to-test
(e) WATER FLOW indicator light	Press-to-test

STARTING AND RUNNING

FIRST ENGINE

1. Proceed as follows: each item to be confirmed by intercomm with, or to, engineer-in-charge.

(a) Engine oil temperature above minimum figure quoted in OPERATING LIMITATIONS	Confirm

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(b) Exterior and interior checks	Completed
(c) Adequate APU air supply	Available
(d) Adequate APU electrical power supply	Available
(e) Air cross-feed valve (if starting No.2 engine first)	OPEN
(if starting No.1 engine first)	CLOSED

Alternatively, when using an external air supply:

(e) Air cross-feed valve (if starting No.2 engine first)	CLOSED
(if starting No.1 engine first)	OPEN
(f) Air ISOLN valves (if starting No.1 engine first)	OPEN
No.1 air isolation valve (if starting No.2 engine first)	CLOSED
(g) MAC valves	Both CLOSED
(h) Engine anti-icing	Check OFF
(j) Check duct pressure	30 p.s.i. minimum
(k) Throttle lever	IDLE
(m) Reverse thrust lever	Forward and down
(n) Booster pump switches	REAR Booster Pumps ON

NOTE: When switching on booster pumps, indication of fuel flow may be observed momentarily on flowmeter indicator. Before selecting 'Start master switch' to start, the flowmeter indications should have returned to zero.

(o) Booster Pump LP lights	OUT
(p) Start master switch	START
(q) Start selector switch	START and MOTOR (Hold momentarily)
(r) Igniter 'ON' lights	TWO ON
(s) LP shaft rotation light	On or flashing
(t) HP fuel valve lever	START: when TGT reaches 400 deg.C or stabilizes, select HP fuel valve lever OPEN

CAUTION: IF LIGHT-UP DOES NOT OCCUR WITHIN 20 SECONDS OF OPENING HP SHUT-OFF VALVE OR TGT LIMIT (SEE BELOW) BEING REACHED, CLOSE HP SHUT-OFF VALVE THEN SELECT START MASTER SWITCH TO OFF. ALLOW ENGINE TO DRAIN FOR 3 MINUTES FROM CLOSING HP FUEL VALVE BEFORE ATTEMPTING A FURTHER START.

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NOTE: Under normal conditions (-10 deg.C to + 30 deg.C) TGT should not exceed 520 deg.C. If this 'alert' value is exceeded, shut down the engine and investigate, as temperatures above this value are normally indicative of pending failure of the air supply system to the engine.

2. After satisfactory start, carry out checks as follows:-

(a) Igniter ON lights	Out
(b) LP shaft rotation light	Out
(c) Oil pressure	Increasing
(d) TGT	Within limits
(e) Reverser unlocked light	Out
(f) Start master switch	OFF
(g) MAC valve	APU

3. Check at stabilized idling:-

(a) Engine oil pressure	22 p.s.i. min.
(b) Oil low pressure light	Out
(c) Engine fuel low pressure light	Out
(d) CSD fail warning light	Out
(e) TGT	540 deg. C. max.
(f) HP r.p.m.	58 to 62%

OTHER ENGINE

Start the other engine, if required, as for normal internal start using the APU, cross-feed start or external supply as required.

To start by the cross-feed method, stabilize the running engine at an HP r.p.m. corresponding to 40 p.s.i. duct pressure, then proceed as for normal start except that the air cross-feed valve must be open.

4. Generators 'on line' check with both engines at idling:-

GEN. FAIL warning lights	OUT

NOTE: It may be necessary to select RESET to bring the generator 'on line'.

NORMAL SHUTDOWN

NOTE: When the engine is shut down from the proximity of cruise r.p.m. it is recommended that the engine is first run at idling r.p.m. for 3 minutes to facilitate uniform cooling of parts.

Proceed as follows:-

(1) MAC valve	Check APU
(2) HP shut-off valve	SHUT
(3) Check LP rundown time	40 sec. minimum
(4) Booster pump switches	OFF
(5) Booster pump LP lights	On
(6) MAC valve	CLOSED

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NOTE: If it is necessary during engine running, to move the MAC valve switch out of the 'APU' position, it must be returned to APU before moving the HP fuel valve lever to SHUT.

REMINDER: WAS THE THRUST REVERSER LOCKING TOOL (Fig.2) FITTED BEFORE THE RUN? CHECK, AND IF SO REMOVE IT AND RECONNECT CONTROL ROD.

EMERGENCY SHUTDOWN

HP fuel shut-off valve	SHUT

NOTE: Adopt emergency shut-down procedure only when abnormal conditions arise, to prevent damage to the engine. If possible, immediately after shut-down the engine should be motored over to minimize thermal distortion. Both rotors must be checked for freedom of rotation when the engine has cooled.

ACTION IN EVENT OF FIRE

ENGINE FULLY COWLED

1.	HP fuel valve lever	SHUT
2.	Fire control handle	Pull
3.	LP fuel indicator	Check X-line; if not X-line, select valve closed
4.	Fire control handle	Turn clockwise to fire first shot
5.	Booster pumps	OFF
6.	Throttle lever	IDLE

7. If fire warning persists after 30 seconds of release of first shot, turn fire handle to fire second shot. If this is unsuccessful, call for use of ground fire equipment.

ENGINE UNCOWLED

The aircraft equipment must not be used, the gas charge being ineffective due to immediate dispersal.

On observing fire warning:

1.	HP fuel valve lever	SHUT
2.	LP fuel indicator	Check X-line; if not X-line, select valve closed
3.	Booster pumps	OFF
4.	Throttle lever	IDLE

5. Call fire team into action

CAUTION: (1) CO_2 FIRE EXTINGUISHANT ONLY SHOULD BE DIRECTED INTO THE ENGINE INTAKE AND EXHAUST COLLECTOR. AN ALTERNATIVE EXTINGUISHANT SHOULD BE USED ONLY IF NO CO_2 IS AVAILABLE.

(2) AFTER USE OF FIRE EXTINGUISHER SYSTEMS, THE POWER PLANT SHOULD BE CLEANED IF NECESSARY.

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ACTION WHEN OVERHEAT IS INDICATED

On observing the overheat warning, DO NOT (INITIALLY) ADOPT FIRE-FIGHTING PROCEDURES, but closely observe the fire warning light, while proceeding as follows:-

1. HP fuel valve — SHUT
2. Throttle lever — IDLE
3. Booster pumps — OFF
4. LP fuel valve switch — CLOSED when engine is stationary
5. Investigate the overheat warning and rectify the fault before restarting the engine.

MOTORING

The limitation for engine motoring is a maximum of three 'dead' cranks (motor) followed by an engine start, the duration of each crank not to exceed 30 seconds with a minimum time interval of 3 minutes between the cancellation and restart of each crank.

1. Exterior and interior checks — Completed
2. Adequate APU or external air supply — Available
3. Adequate APU or external electrical power supply — Available
4. Air cross-feed valve — OPEN
5. Air ISOLN valves — Both OPEN
6. MAC valves — Both CLOSED
7. Engine anti-icing — Check OFF
8. Check duct pressure — 25 p.s.i. minimum
9. Throttle lever — IDLE
10. Reverser thrust lever — Forward and down
11. Start master switch — MOTOR
12. Start selector switch — START AND MOTOR, hold momentarily
13. Igniter 'ON' lights — OUT
14. LP rotation light — ON
15. Oil pressure — Observe pressure rising

CAUTION: IF LP SHAFT ROTATION IS NOT INDICATED WITHIN 10 SECS. SELECT START MASTER SWITCH OFF.

On completion of motoring cycle

16. MAC valve — APU
17. Start master switch — OFF

When engine has ceased rotation

18. MAC valve — CLOSED

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